NOTES

ON

FORESTRY.

DEPARTMENT OF AGRICULTURE INDIA REVENUE & COMMERCE

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BY

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"Die Grundsätze der Forstwirthschaft sind aller Orten die nämlichen, nur verschieden nach dem Material und den Verhältnissen, auf welche sie angewandt werden Vieles lässt sich in einem Naturwald erst anstreben; das Endziel der Forstwirthschaft zu erreichen, kann Generationen kosten, bleibt aber stets ein Werk der Humanitat und Civilisation wie des wirthschaftlichen Nutzens."

BURCKHARDT.

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DEPARTMENT OF AGRICULTURE

NOTES ON FORESTRY.

CHAPTER I.

INTRODUCTION.

THE primeval forests, once occupying we know not now how much of the vast peninsula of India, have, in the ordinary course of cause and sequence, gone down before the spread of a civilisation supposed to have extended over nearly four thousand years, to make room for an industrious and increasing population.

This has ever been the fate of forests in all civilised countries; but in the harder North there has always been a stage in which civilised communities, animated by the need of warmth and shelter, have interposed checks to further inroads on forest area. Local climatic conditions have rendered these influences to a great extent dormant in India. There was little need for fuel in a country in which the sun gave more than warmth

enough throughout the year; little need for timber where the rudest huts supplied the necessary shelter. The habits of the people were simple, their wants few; and such forests as escaped the clearing axe of the Hindu appear to have owed their preservation rather to their non-suitability to agricultural purposes, or to the fact that there was an ample area of already cleared land, than to any purposed check based on the recognition of the fact that a greater or less proportion of forest area was necessary to the general well-being of the people. It is probable that, for long periods in the history of India, the increase of population was scarcely appreciable: areas redeemed from the forest in times of peace had been allowed to run waste in time of war, and the alternate resumption and abandonment of such tracts so far occupied the energies of the people as to remove all temptation to trench further on forest area. The Hindu appears never to have reached that stage in which the threatened extinction of the forests is recognised as an impending calamity.

The invasion of Mohammedan conquerors appears to have been followed by the purposed conservation of such remaining forest tracts as were readily accessible. Uninfluenced by the tenderness for animal life which characterised the Hindu rulers,

but often, on the contrary, keen sportsmen, they constituted the forests game reserves, and severe penal rules were sometimes promulgated against even the removal of a stick.

But throughout the whole period of their domination in India, it does not appear that there was ever such a demand for land for agricultural purposes as to render further forest clearance necessary. On the contrary, there is evidence of such an anxiety on the part of the great talookdars and zemindars to secure settlers on their lands, as justifies the assumption that the cultivable area was in excess of the available labour.

But with the advent of the British power in India came a new era in the history of Indian forests. The spread of a higher material civilisation, the dominance of a power mighty enough to restrain internal war, and animated by a disposition to foster every industry, gradually introduced such a feeling of security among the people at large as encouraged them to the display of more domestic comfort and luxury than they had dared indulge in under the rapacious eyes of former rulers, and heavy drains were now made on the existing stock of the remaining forests. Peace and growing prosperity, aided, perhaps, largely by the check given to the ancient

practice of female infanticide, tended to a rapid increase of population; and side by side with the inroads now being made on the forests for their products, came a demand for the land for cultivation. English rulers, bred in the traditions of a country in which coal and iron were the chief factors of material progress, instead of regarding with dismay the threatened extinction of the forests in the face of a growing demand for timber, hailed the spread of cultivation with unmingled feelings of self-congratulation, and vied with each other in "converting the forest into smiling cornfields."

This destruction of forest area, keeping pace with a rapidly-growing demand for timber, soon directed attention to the mountain ranges of the country, in which the unsuitableness of the soil for cultivation had hitherto secured its maintenance as forest. The outer and more accessible ranges came first under tribute; large areas were laid bare by contractors, who had no thought of providing for reproduction; and the soil which had accumulated under ages of forest shade went down the steep hillsides before the monsoon rains, leaving only the bare rock, from the crevices of which had sprung up a sparse and stunted vegetation, in place of the whilom noble forest. Farther and deeper into the ranges

went the woodcutters, felling every valuable tree before them, unmindful of the formidable obstacles to transport, which prevented more than a small proportion of the felled timber coming to market.

Deciduous mixed forests, too, were drained of all their best varieties of timber, and the forest acquired a new feature, by the predominance of inferior kinds and worthless crooked timber.

The urgent necessity of doing something to avert the total extinction of the forests, or, at least, what was almost equivalent to it, the destruction of their value by mismanagement and neglect, became at length recognised with more or less force, and some twenty years ago a Forest Department was formed for the better administration of the remaining forests.

The difficulties which the new Department had to encounter were almost incalculable. England, with its vast wealth of iron and coal, was in a measure independent of forest products, and, if we except Evelyn's "Sylva," had no forest literature of any value as applied to this country. Ruined forests were to be treated systematically by men who, whatever their general abilities—and many of them, at least the provincial chiefs, were men of no mean ability as botanists—were nevertheless not only unacquainted with the first principles of the science of forestry, but, for the most

part, did not know where to turn for instruction. Much of the mischievous tendency of past operations they were able to repress or restrain; but the Forest Department was naturally regarded as a revenue department, and, in the effort to achieve satisfactory financial results, the prevailing causes of mischief were often perpetuated, although within narrower limits.

Fortunately there soon came to the front a man who grafted on the experience gained in this country a knowledge of scientific forestry as understood in Europe, and who, from his position as Inspector-General of Forests, has been enabled to permeate the Department with correct views of the ends and aims of forest administration. (I refer, of course, to Dr Brandis.) He has, moreover, provided for filling up the ranks with specially-trained men, whose experience, gained in the executive grades, and grafted on those broad principles acquired in the schools of France and Germany, will in time fit them for dealing with those weighty problems in the administration of Indian forests which for the present sorely vex us.

To these men, trained in the schools of France and Germany, the forest literature of those countries is accessible; but, in the advanced state of the science in those countries, the literature

deals so largely in details, that the student must needs wade through a great mass of it to arrive at a clear view of the broad general principles on which the forest administration of those countries is based. Moreover, for the great mass of Indian forest officers, it would be impossible, or at least a work of difficulty, to spell through technicalities in a foreign language; and, moved by these considerations, I have been tempted to pen the following pages, in which I have endeavoured to adapt my Indian experiences to the principles taught in Germany, for my general knowledge of which I am mainly indebted to Forest Director Burckhardt, who, to a comprehensive view of forest administration, and an intimate acquaintance with every detail of executive work, adds a singular facility in imparting information, and a genial nature, which rarely fails to affect those who have the good fortune to come into contact with him with his own enthusiastic love for the "forest shades." I have further endeavoured to lay before the reader the general features of such of the German methods of forest management as promise to be of useful application to our Indian forests; but I have treated only of their general features, being impressed with the idea that a clear comprehension of these is of more importance in the present state of the science

of forestry in this country, than a mass of technical details, not always applicable to the diversified conditions of Indian forests. Broad principles are of world-wide application, but in matters of detail we must base our own system upon our experience of local conditions.

There is yet another object which I have had in view in penning these pages. The Forest Department has been subjected to severe outside criticism. In one place, financial results appear utterly inadequate to the area under the control of the Department; in another, financial results may be satisfactory, but the work not being in part of a definite plan based on known data, there is a suspicion that the future well-being of the forests is being sacrificed for present returns. These criticisms are of the greatest advantage in keeping persistently before every forest officer a knowledge of what is required of him, and the necessity of a precise acquaintance with the capabilities of his charge; but while, on the one hand, these criticisms are in many instances essentially just, it may, on the other hand, be fairly urged that sufficient allowance is not always made for the ruined state in which some of our forests came into the hands of the Department, and the consequent impossibility of securing satisfactory financial results, with due regard

to the permanent maintenance of their capabilities.

Some gross mistakes have unquestionably been made in the past—such as felling large quantities of timber which were sold at an absolute loss upon costs; but such mistakes could only have been made in ignorance of the relation of costs to market value, and not in pursuit of any recognised principle that it was necessary to do something, if even at the cost of impoverishing the forests. But it is even yet to be feared that, in some instances, where seemingly satisfactory financial results are achieved, there is not that attention to reproduction which alone can justify the expectation of the permanent maintenance of the yield.

The golden rule for the forester is—to maintain his forest at its highest capacity of production; to cut out annually an amount equal to the annual increment; to reduce transit charges to a figure which shall secure him a market for his whole produce; and where natural difficulties render it impossible to take timber to market at a profit, to sell such portion of his annual increment as he can locally, reserving the forest for a future day; or, if it is in the Hills, for its importance in the general economy of nature, apart from direct financial considerations.

These ends can only be achieved by systematic

management; and the author hopes that the following pages will be of assistance in indicating the means to the desired end. This little work makes no pretension to a complete scientific exposition of the subject; but the writer, strongly impressed with the difficulty of first steps, has laid before himself the modest attempt to smooth away preliminary difficulties for such as need it. The object sought to be attained is mainly the laying down of general principles, in such clear language that one who had never before given the subject a thought might rise from its perusal with a good general idea of what to do and how to do it.

CHAPTER II.

SOWING.

In primeval forests which have escaped the influence of the woodman's axe—and such are still to be found in the remote recesses of the mountain ranges of India—we find trees of all ages, from the seedling of a few years' old to the hoary giant that has braved the storms of centuries. As a general rule, these purely natural forests do not consist of trees of all ages growing promiscuously together, but are divided naturally into blocks, in each one of which the trees are of a nearly uniform age. Among the younger groups are sometimes to be found scattered giants of an older growth: these are the trees of a past generation, which have outlived their fellows, and lead to the inference, established by a variety of considerations, that the young forest beneath them is the offspring of an older forest, of which they are the survivors, and doubtless of many past generations of forests. If we now turn our eyes

to another hillside, only dotted with large trees, and the interspaces at foot covered with a dense undergrowth, or deprived of its rich carpet of humus, and supporting only grass, we should not infer, in the case of gregarious trees, that the existing sprinkling came up under present conditions, but that they are the survivors of a once close forest, the mass of which went down under conditions unfavourable to reproduction. Careful research has established the view that perfect and thorough reproduction is largely dependent upon a gradual removal of the existing older stock. In the rich forest soil of the Plains, if a forest tract be cleared, there will ordinarily spring up a mass of coarse herbage and undergrowth, through which coppice shoots may readily find their way, but through which young seedlings will rarely be able to struggle; and on steep hillsides the chances of reproduction following a clean sweep are still more precarious. Under the forest shade the soil is in a state of perpetual increment from humus afforded by decaying foliage and trunks; the roots hold it together; the branches break the violence of the rainfall; the spongy absorbent nature of the soil enables it to retain it; and this, slowly sinking into the underlying rock, preserves the needful moisture in the soil, and becomes the source of perennial springs. But if such a moun-

tain forest be suddenly laid low, we have not only to fear the sudden appearance of an undergrowth prejudicial to tree reproduction, but we have to fear the total loss of the soil, which, exposed to the violence of the falling rain, and no longer held together by the tree-roots, gets washed down into the valley below, until the bared subsoil or rock is unfitted for the support of any but the scantiest herbage.

Turning now to the compact forests in search of Nature's method of reproduction, and going from blocks of poles of twenty feet high, through every succeeding stage, to blocks of mature trees, we find the number of trees on a given area diminished at every stage to make room for the gradual perfect development of the survivors; and as long as the forest is full, although we may find delicate seedlings of the year, we shall find none of two or more years old: the trees, closing at top, do not admit sufficient light to foster such seedlings as annually germinate. But passing on to a block in the next stage, in which mature trees are going to decay, we find an occasional fallen tree, the site occupied by which is covered with a dense carpet of seedlings. Year after year fresh trees crumble to decay, admitting sufficient light to foster the seedlings which spring up annually, at first in spots, and finally throughout the whole area, but

short of that full light which fosters the appearance of dense undergrowth; and by the time the bulk of one generation has disappeared, a succeeding generation is sufficiently strong to hold together and shelter the soil on hillsides, and to triumph over the undergrowth of shrubs in any condition. Nature's method is simply the gradual admission of sufficient light to foster the young seedlings, and short of that full light which would leave them to struggle with rank undergrowth before they have attained to the necessary strength for a successful struggle.

This method I found largely imitated in Germany; but the German forester, instead of waiting for his trees to decay, attacks them at maturity, thinning out the block at first only lightly to foster germination, then to admit more light to encourage healthy development, reserving the clean sweep until such time as the forest is covered with a new and vigorous growth. The period between the first thinning and final clearing varies from ten to thirty years. On the plains of India, such is the rapid growth of some of our trees in their earlier stages, as compared with the rate of growth in Europe, that it will probably not be desirable to extend the period beyond two or three years; but this difference of conditions does not affect the principle, which is the admis-

sion of as much light, and no more, than is necessary to the well-being of the young crop at every stage.

In South Germany, where the period is frequently protracted to thirty years, it is based less on the necessities of the young crop than on the ascertained fact that, in a forest in which the trees have already been drawn up to their full height, a sharp thinning out, to an extent that allows every tree to stand alone, results in the production of as large an increment as would be made by a close forest of the same area, and of a larger class of timber than could be grown in close forests—a fact of the utmost importance in the treatment of our plantations of naturally non-gregarious trees, such as sissoo, to which further reference will be made in the chapter on thinning.

This is the simplest and most economical of all systems of reproduction, and is especially applicable to forests of deciduous trees.

This method is sometimes supplemented by hoeing the ground to a depth of a few inches in small spots a few feet apart, a method facilitating the lodgment of the seed, and insuring its taking root, especially in hard or stiff soils.

If it is desired to substitute another class of tree for that now growing in the forest, the seed of the required class should be scattered over the forest

at the proper germinating season following the first light thinning.

If the newly-introduced seedlings are as hardy and of as rapid growth as those they have to contend with, they may be left to take care of themselves; but if they are less hardy, or of slower growth in their first stages, we must help them in the struggle by keeping down their opponents for a while.

But there is sometimes a demand for plantations in grass-lands, or lands not previously occupied by forests; and here recourse must be had to artificial sowing, the method of which will vary with local conditions and the character of the seed.

All cattle being of course rigorously excluded, the principal difficulties to contend with are the present occupants of the soil, and temporary lodgments of water upon the surface. Some of the finest timber trees spring from most delicate seedlings, as tūn, sissoo, eucalyptus. These can hardly struggle through rank grass, nor can they stand being submerged for a few hours at this stage, nor, on the other hand, can they struggle through a drought of a few weeks' duration.

The system best adapted to overcome these difficulties in ordinary grass-land is that of turning over the sod grass to grass, and sowing on the inverted sod. If the sod is taken thick enough—

five or six inches—there will not only be no seed of indigenous plants on the new surface, but the sown seed coming up on an elevation of a few inches above the surrounding soil, the seedling plants have no foes to contend with in their first stages.

In irrigated plantations, or where operations are on such a large scale as to necessitate preparing the ground before the rains commence, the best way to give effect to this principle is to trench the land in lines at distances proportioned to the rapidity of growth and the market value of saplings, and with the earth thrown out from the trenches, forming a compact bank sloping back from the edge of the trench, and about six inches high. The irrigation water flowing through these channels, or the rain lodging in them, concentrates all the moisture in the subsoil at the lines, which guards the plants against the evils of a long drought, while their elevation guards them from all danger of being flooded; moreover, the bank preserves for a long period that looseness of structure which facilitates the passage of the young roots.

If the plantation is irrigated, the chief point demanding attention is that the first watering be sufficiently liberal, and maintained long enough for the ridge to be saturated by upward percolation.

If the watering be by rainfall, throw the ridge

back six inches from the trench, spread it out to a good width, and beat it down compactly, that the rain may not wash the earth into the trenches. This method has proved very successful in the Punjab plains, the cost of collecting seed, trenching, banking, and sowing being about eight rupees per acre, with the trenches a foot wide, a foot deep, and fifteen feet apart.

I know no method of sowing to compare with it where irrigation has to be resorted to; but in *sailaba* lands, sown on the subsidence of the river, and free from undergrowth, hardy seedlings need no more preparation of the soil than a light scratching of the plough.

In localities where the rainfall is insufficient for cultivation, and where irrigation water is not available, there are often large areas of waste dotted with stunted trees—Prosopis spicigera, Capparis aphylla, &c.—requiring little moisture for their support; and the question of stocking these uniformly for fuel reserves may sometimes crop up.

Here the first question for consideration is, Did the trees now standing spring up under conditions of moisture similar to those now existing, or has some once-neighbouring river shifted its channel to a distance, and the withdrawal of moisture destroyed all trees excepting such as had their roots deep down in the soil? In this latter case, it would be

labour lost to attempt re-stocking it; but if the conditions remain unaltered, such land may possibly be stocked by rigorously excluding all cattle, and scattering the seed in plough-lines in exceptionally moist seasons. I say "possibly," for much depends on uniformity of soil. If the trees now standing are found only on mounds of humus, with the intervening spaces excessively impregnated with saline matters, it would be vain to attempt stocking it.

In connection with sowing, it should always be borne in mind, that although most tree-seeds, if kept dry, will remain good for an indefinite length of time, if they are once moistened sufficiently to cause them to swell, they will immediately rot, unless sufficient moisture is supplied to foster germination and growth.

These are general remarks: special seeds require special treatment. Tūn-seed must be collected before it is quite ripe, or the capsules will have opened and shed the seed; but it must not be sown until the capsules have burst, and the seed separated from them. Sal-seed germinates on the tree, and if it is required to sow it in ground not yet prepared, or to keep it until the soil be properly moistened, it may be kept for a few weeks spread out on sand in a shady place, and well sprinkled with water twice a day; but it will require careful handling

in removal. Teak-seed, if collected and sown immediately, will generally take a year or two to germinate; but if a pit be dug, and the bottom filled to a foot deep with sand, the seed spread thickly on this (2 to 6 in.), and covered with another foot of sand, and the whole mass well watered, it will be found, on opening it at the expiration of three or four weeks, that germination has already commenced. If it be now taken out and sown, it will spring up almost immediately, provided it be kept well watered. Many of my readers will probably be acquainted with other peculiarities of other seeds, but we want a ready means of communicating such small but not unimportant items of experience.

In any ordinary system of sowing, we cannot count on more than a small and irregular percentage of the seed germinating; we have consequently to sow far more seed numerically than we want trees. This involves an early and unreproductive thinning, or the plants are left to struggle with each other until the thinnings have a market value. This struggle, which ends in the weaker plants succumbing, is always carried on at some little cost to the survivors, but its lasting injury is inappreciable if the thinnings in the next subsequent stages are conducted with prudence and moderation.

On these grounds many foresters advocate the resort to planting for the more valuable trees—a system which admits of the plants being placed at once at the required distances apart; and although it requires a greater first outlay, this is supposed to be well compensated for by the saving of cost of early thinning, and the more uniform and healthy development of the plantation. Moreover, where seed of the required variety is scarce, the greater care which it is possible to give to the preparation of soil in nurseries renders it often possible to stock a plantation on this system with five per cent. of the seed that would be required to sow it.

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CHAPTER III.

PLANTING.

THE first step preparatory to planting is the formation of nurseries, for the proper irrigation of which some provision is generally necessary.

The soil should be thoroughly well worked, and divided into small beds: long and narrow ones are the most convenient. These beds should be raised, and the water allowed to flow in the channels between them, just rising over their surface if they are too wide for the water to find its way through them by capillary attraction. If the soil is dry at the commencement of operations, it should be well irrigated before a spade is put into it: dry soil can never be properly worked.

Where irrigation is not available, and the rainfall scanty, it may be desirable to sow rather in sunk than in raised beds, to economise all the moisture; but measures should be taken to drain such beds in the event of a heavy rainfall.

The best manure for nursery beds is leaf-mould, but many authorities deprecate its employment, especially for plants that have afterwards to be

removed to a poor soil. I do not quite agree with this view, believing, rather, that the stronger and more vigorous a plant is, the better will it be able to cope with hardships; but some two or three weeks before a plant is removed, it is desirable to check the water supply to prevent the formation of too succulent shoots, and this remark is especially applicable to transplanting from a richer to a poorer soil.

The beds being prepared, the seed may be sown broadcast, and covered in either with a small garden rake, or by lightly sprinkling fine mould over the surface; but a better mode, because more convenient for removing the plants, is to sow thickly in lines 6 to 12 in. apart.

These lines are trenches half an inch to an inch deep, according to the size of the seed, small seed being always very lightly covered; but I get the best results from ridge-and-furrow beds, sowing on the top of the ridge.

With the exception of oaks and walnuts, which an occasionally transplanted three or four times, and allowed to attain a height of 8 to 12 ft. before they are removed to the forest, plants are seldom kept more than three years in the nursery; but three-year old plants in a European nursery rarely exceed 18 in. in height. Seedlings of one year old are sometimes transplanted to their place in

the forest, either singly or in bunches of three to five. Others transplant these at 8 to 10 in. apart in the nursery, removing them to the forest the second year, planting them singly; while others prefer transplanting them a second time in the nursery at 9 to 12 in. apart, removing them to the forest the third year. These frequent transplantings cause the roots to be much branched, which enables them the more readily to assimilate food when removed to changed conditions, and facilitates their removal by preventing the formation of too deep a top root.

This system, which may be advantageously adopted for the cultivation of deodar and other hill-trees, involves generally too long a period for trees on the Plains. Many of our trees, if sown in nurseries in March or April, will reach a height of 1 to 2 ft. by the middle of July, and require to be planted out immediately, otherwise the labour of removing them becomes too costly. For forest work, I do not think it necessary to keep any of our stock plants more than one year in the nursery, unless for planting in rank grass-jungles; and here it is generally cheaper to put out the plants at 6 to 8 ft. high, than to clear the jungles. As soon as the trees meet overhead, the undergrowth will die out, and leave a clean forest floor.

Almost infinitely various are the methods adopted in the final planting-out; but the principal points for consideration are, first, whether the soil is to be loosened throughout, or only in strips or spots; secondly, whether the moisture is scant or superfluous.

If it is determined to work the ground over the whole surface, it should receive two or three ploughings with a native plough, be cleaned of weeds, and then turned over with the hoe to a depth of eight or ten inches.

If the ground is to be worked in strips only, it is better to plough over the whole surface, and then with the hoe dig up the strips intended to be planted. A convenient width for these strips is 5 to 8 ft., with interspaces of similar width; the guiding principle being, to have the strips wide enough to carry a double row of plants, and the interspaces not so wide as to leave room for marketable poles to be grown between the strips. Such wide strips not only involve waste of land, but tend to the too early development of lateral branches.

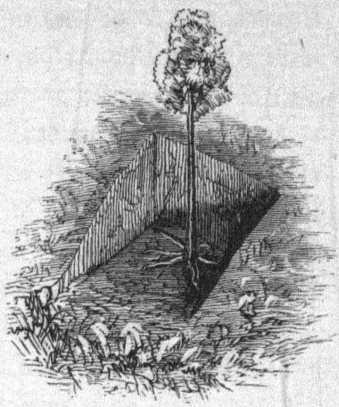
When the soil is not easily worked, or where, from the absence of water, it is impossible to get it ploughed before the planting season, trenches a foot deep may be dug at 10 to 15 ft. apart for quick-growing trees, and at 5 to 8 ft. for such trees as grow slowly at first.

Planting is usually conducted during the rains; and if the soil is liable to be submerged for any period, the soil from the trenches should be thrown up, and a compact bank formed at the edge of the trench. In the strips, the soil can either be thrown up from the outer edges on to the centre, or, in the wider strips, from both the outer edges and the centre, so as to form a double ridge.

In planting in spots, which is the most economical method, holes 10 to 12 in. deep are made at the intervals at which it is determined to plant: 5 to 8 ft. is a convenient distance for the Plains. Making these holes with native implements is generally a costly one compared with the quantity of earth removed. There is no room for the hoe to reach the bottom, and resort is generally had to the *rumba* to finish the holes—a method involving a ridiculously large outlay, a coolie being employed the whole day in making twenty or thirty holes. If the soil be first well soaked, a good man will make 250 holes a day with the semi-cylindrical-shaped spade figured in the margin—a rate which admits of holes being made at time of planting. This is made wholly of iron, the blade being about 8 in. in the curve, and being inserted into the soil to the required depth, a twist is given which

carries the blade round the whole circle, when the earth can be raised with the spade in one piece. This implement is useful in removing seedlings of rare trees from the nursery.

On hill-slopes, planting in spots is the usual method. A cord, knotted at the required distances, marks the spots to be planted; and the soil is dug out from the face of the hill as in the diagram, so as to make a flat surface for the roots to rest on. This operation should always be carried on from the top of the hill downwards, otherwise the plants are in danger of being trodden on.



REMOVING THE PLANTS.

A fruitful source of failure in planting operations on the Plains is the injury caused to the roots and young shoots by exposure during removal, which may be guarded against by attention to the following directions.

Transplant only during rainy or cloudy weather, or in the evening after four o'clock.

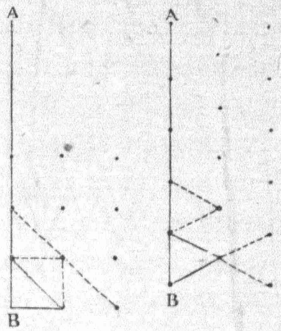
Provide a few large earthen pans, about a foot deep, and in these mix a compost of fresh cow-dung and water to the consistence of cream. Then dig out the plants, first cutting away the earth in front of the lines to the full depth of the roots. If several plants are held together in one lump of earth, do not pull them apart, but raise the clod, and drop it, when the plants will fall apart without injury to the roots. Immerse them immediately in the compost-pans, leaving them there until a coolie-load is ready. Then place the plants in baskets on a layer of fresh-cut grass or herbage, covering them over with similar material. In this state they may be carried to the forest without risk; but more should not be despatched at once than can be planted in an hour, unless the distance is great and the weather damp.

If the plants be kept without water a week or two before removal, it will check the formation of tender shoots, and thereby lessen the risk; but the beds may be watered the day before the plants are wanted, as this will facilitate their removal.

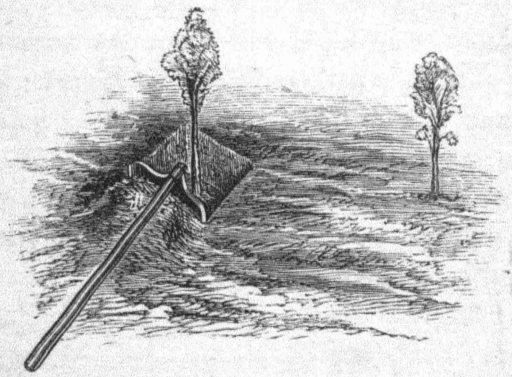
These appear but trifling matters, but attention or inattention to them constitutes all the difference between success and failure.

PLANTING IN THE FIELD.

Trees are generally planted either in quadrate or quincunx order, and the spots are conveniently marked by triangles of the required dimensions, made by tying three sticks or stout reeds together; for the former a right-angled triangle, for the latter an equilateral triangle.



A guiding line, A B, having been first laid out, the position of subsequent lines is easily maintained, a little pains being taken to instruct the coolies at the outset.



In soil already worked with plough or hoe, planting may be performed with the hoe, which, on the spots being marked, is struck in, and the earth behind the blade drawn towards the striker sufficiently to make room before for the insertion of the plant, which is then placed down in front of the blade, on removal of which, the soil, if loose, falls back in its place, and should be firmly pressed down round the roots.

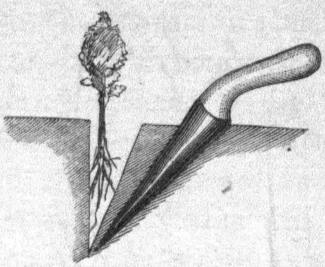
In planting in holes in unworked land, one man walks before and makes the holes, and another, following him with the basket of plants, first throws a little loose earth into the hole, places the plant, holding it upright with one hand, while he breaks in the earth with the other; and the hole being filled, the earth is firmly beaten in. If this latter precaution is neglected, the plants will die unless the duty is performed by an early shower.

There is no difficulty whatever in planting, but the mode adopted must be suited to the local conditions of soil and climate; but to secure success with economy, care must be taken to organise the labour at first, so that one man shall not have to wait for the other.

In 1871–72, I observe in the Punjab Annual Report, that 871 acres were planted in the Changa Manghu plantation in seven days—a result that

could not have been attained without a well-organised system.

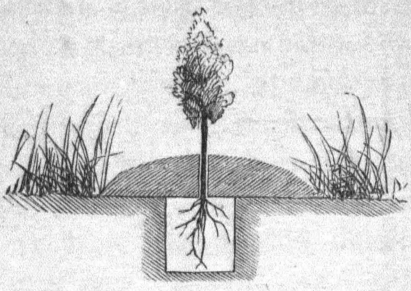
In light alluvial soils, or in soil that has been loosened, a little iron-sheathed wooden implement, as in the margin, does very well for small plants, and can be used by women and boys. This is inserted in the soil, and worked backwards and forwards until the hole is large enough to receive the plant, which being placed, and held upright with one hand, the implement is again inserted at a few inches' distance, and the soil thrown forward around the roots. It is not necessary to fill up this second hole, which forms a little water reservoir.



In provinces in which there are winter frosts, it will rarely be necessary, and always dangerous, to water plants from November to February inclusive—a point first impressed upon me by Dr Brandis, and amply confirmed by subsequent observation. Of course, care will be taken to conduct planting operations only when the soil is sufficiently moist to foster development, or when the means of irrigation are immediately at hand.

In planting in coarse grass-lands, it is a good plan to make the hole three or four inches less than

the required depth, and then cutting a circular sod of fifteen to eighteen inches diameter, divide it across the middle, and invert it so as to embrace the plant as shown in the annexed section. This will secure a free space around the plant, admit the needful light, and preserve it from having to struggle with the grass; and if the soil be too moist at the season of planting, the plant, instead of being lowered into a hole, may be just rested on the ground-level, and sufficient soil be heaped up round the roots to fix it firmly.



A great advantage in nursery operations is the possibility of bestowing more care on the manipulation of the soil than can be given to forest areas, but even in nursery beds it is difficult to give that extreme care which some fine and rare seeds require—that is, if we would have a plant for every good seed; as, for example, with the eucalyptus, with which, operations being for the most part on a limited scale, it is better to resort to pots. Seedling pots should be large, and have a large hole in the bottom; they should be filled the first third with broken fragments of brick or pottery,

and the remainder with friable loam mixed with well-decomposed leaf-mould.

The seed, being sprinkled rather thickly on the surface, should be very lightly covered, and either placed out in the rain, or kept in a shady spot and freely sprinkled with water from a watering-pot morning and evening. When the seedlings have attained a height of two or three inches, they should be transplanted into small pots singly, or if the operation is on a larger scale, into a finely-prepared nursery bed, at three or four inches to a foot apart, where they should stay until the following rains, when they may be taken out singly with the holemaker, without disturbing the earth around the roots.

CHAPTER IV.

THINNING.

In self-sown natural forests, and even in artificially raised plantations, we find in the first stage as many as from fifty to a hundred plants occupying the space required by one mature tree. This is as it should be, for the plants being close together, can develop only upwards towards the light, and thereby acquire at the outset that tall straight form which results in the greatest percentage of timber, and generally in the most valuable timber; but it is evident that before any one of these fifty or a hundred trees, as it may be, can reach maturity, the others must be all removed.

Natural forests of gregarious trees thin themselves; that is, there is a struggle for existence, in which the weakest succumb at every stage, thereby making room for the development of the dominant trees for another stage. This is done by every second or third tree rising above its fellows, and these dominant trees, spreading out their branches

towards each other, exclude the light from those left behind, which cease growing, and gradually die; and this process being repeated at every stage of growth, the fifty or a hundred saplings are at last reduced to one mature tree.

In thinning forests of gregarious trees, the German forest officer usually leaves the matter to Nature, until the poles have attained a market value which leaves a profit on cutting out, and then he follows Nature closely by cutting out only those trees which he sees are being domineered over,—trees of useless timber which have sprung up spontaneously, or distorted or damaged trees, which, although they may dominate, will not make good timber; but when the remaining trees have been thus drawn up to nearly their full height, it is sometimes thought advisable to thin out sharply to the extent of 50 per cent., or as much as will leave each remaining tree the necessary space for its full development, by which means larger timber is secured than is to be found in forests in which the trees are allowed to struggle with each other to the end.

In Scotland a somewhat different method is commonly pursued. The Scotch forester frequently thins out the best-developed stems, on the theory that he thus not only secures a better immediate return, but that the reserved trees, although they

have lagged a little behind in the struggle, will almost immediately recover lost ground after the free admission of light.

But all trees are not naturally gregarious. Many valuable timbers, although sometimes found struggling with other trees in close forests, will never under such conditions acquire those noble dimensions attained by such trees growing singly. Such trees are light-loving, and, if grown in dense plantations, will draw each other up to an extent that renders them all spindly and unhealthy; and a sharp thinning out, if delayed too long, instead of remedying the evil, will sometimes result in their all going down before a strong wind. They have grown beyond their strength, and are unable to withstand the violence of the storm. Such trees require not only an abundance of light, but a broad-spreading crown, with ample foliage for absorption of atmospheric food. Nevertheless, as long timber is usually a desideratum, it is advantageous to grow such trees in plantations; but while planting them closely enough to encourage their drawing each other up, thus fostering a straight upward growth, we should never leave them so close that they crowd each other. Thinning out should be resorted to directly their branches come in contact with each other, and when the forest has attained the required height,

the thinning out should be so sharp as to leave every tree standing alone.

The evil effects of neglected thinnings may frequently be seen in artificial clumps of sissoo in the Punjab, in which the trees have been allowed to draw each other up until a dead-lock has set in, and increment almost entirely ceased in all but the outer trees of the grove, whose cubic contents, taken singly, will sometimes equal that of half-a-dozen of the poles within.

After such a sharp thinning out as above indicated, the forest floor is advantageously covered with a shade-loving undergrowth or coppice. This shades the ground from the direct rays of the sun, preserves its moisture, enriches it with fresh deposits of humus, thereby fitting it for the reception of a new crop after the timber shall have been felled, and gives at the same time a money return while the timber is growing.

In Germany I saw the hornbeam much grown under oak; and for this country, the tūn and mulberry are shade-loving trees with serviceable woods, that might be advantageously grown under similar conditions.

The German forest officer, while directing thinning operations, is always anxious to clear out all trees of inferior classes that threaten to crowd out more valuable timbers; and by persistence in this

course all valueless trees are at length exterminated. In India we have forests of mixed timbers, of which perhaps only one kind is in great demand; this one kind has been frequently treated on precisely the same method adopted by the skilled forester for the suppression of inferior kinds. It has been persistently cut out as soon as the trees attained a marketable value, and the inferior varieties left in undisputed possession of the soil. If this course be persisted in, the extinction of valuable timbers in mixed forests is only a question of time.

It is quite true that such trees have no value unless they are felled, but the fellings should be arranged on such a method as to provide for the appearance of their seedlings under conditions which admit of their development unhampered by the pressure of tall trees, with which they could not successfully contend.

In all mixed forests in which there are only one or two valuable species, and those not in preponderance, there should be periodical thinning inspections, during which every tree threatening to interfere with the healthful development of trees of the more valuable classes should be remorselessly cleared off, or at least girdled, if they have absolutely no market value; and further, all valuable trees, within twenty years of coming to the axe, should have a space cleared round them, either

by simply girdling the neighbouring trees, or by felling and burning them on the ground, which latter is an excellent preparation of the soil for seed germination; and then, on the removal of the valuable tree, we should have a clump of its seedlings, some one of which would survive to replace it.

By attention to these rules we assist valuable varieties in the struggle with the inferior, and pave the way for their ultimate predominance.

Finally, under this head the golden motto for the young forester is "Do not do too much." It is quite true that in a young forest, if every tree has ample room for further development, it will make more wood than it would in a close forest; but, on the other hand, it must be borne in mind, first, that the ground would support two or more trees in the place of one; secondly, that by fostering early lateral development at the expense of height, we reduce the ultimate yield; and thirdly, the admission of too much light fosters the appearance of a frequently noxious, and sometimes in India an impenetrable, undergrowth. Even damaged and crooked trees and inferior species, although marked for removal, should not be cut out until they threaten to interfere with the growth of more valuable trees; and in thinning or girdling in mixed forests to foster the

spread of valuable timbers, care must be taken to perform the operation with an eye to that gradual admission of light indicated in the chapters on sowing.

If we could unravel the history of any pure forest of gregarious trees, we should probably find that in some remote past it was a mixed forest, in which many varieties struggled together for possession of the soil, and that it became a pure unmixed forest in consequence of the now dominant variety having been endowed with special qualities, such as greater rapidity of first growth, greater height, greater longevity, greater strength to resist snow-brook, a form which did not admit of any weight of snow resting on its branches, or some one quality or combination of qualities which, specially adapting it to local conditions, resulted in its final triumph and the extinction of all less favoured varieties.

This same struggle is still going on in all mixed forests, and by cutting out only the more valued varieties, we assist the less valued in the struggle; but, recognising Nature's mode of operations, we should always study to foster the spread of those species and varieties most in demand.

CHAPTER V.

FELLING.

UNDER this head little need be said. In felling on hillsides, it is better to fell the tree against the hill, both because it is less apt to damage it, and because in this position it is easiest worked out when the forest is being restored by natural reproduction.

The principal point requiring attention is to conduct the operation of felling in such a manner as to cause the least possible injury to young plants. For instance, in felling on a hillside, we should not begin at the bottom, and then, after a young growth had come up, slide the timber from above over it. Moreover, where the hillside is too steep to admit of sliding down the timber without damage, by beginning above we can make use of the lower trees as helps in lowering the log gradually.

Timber felled among, or allowed to slide over, quite young seedlings does not cause much dam-

age, as these young seedlings will generally rise again after the pressure is removed; but in a young growth of from six to thirty feet high, timber can hardly be felled without damage. Among older trees, again, there is generally room to fell timber without injury.

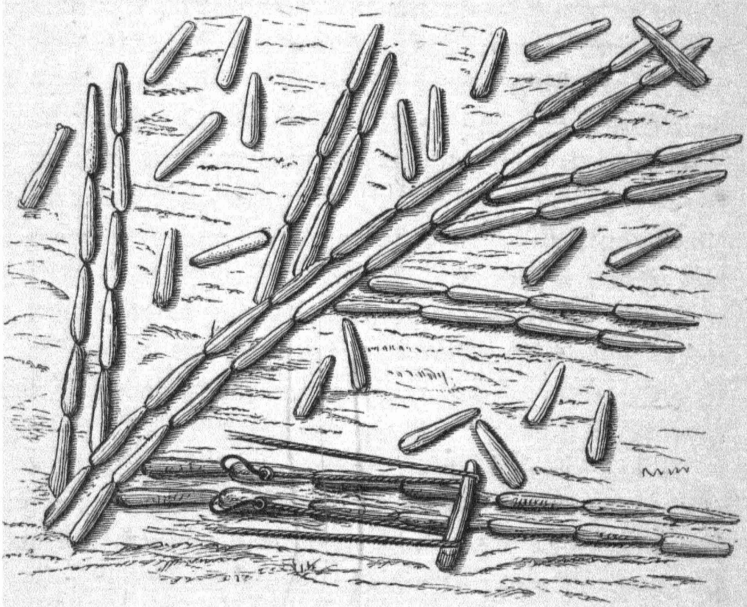
CHAPTER VI.

TIMBER TRANSPORT.

A SIMPLE but important fact to be borne in mind is, that logs move much more freely without their bark than with it, and that, being barked, they will travel much more freely on each other than on the ground. Also, that long logs, once set in motion (endways), will slide down a lower incline than short logs. Large timbers will also slide at a lower incline than poles.

To move timber on level ground.—Timber is most economically transported in water, but forests on the Plains are frequently some miles from the nearest river, and often in remote localities, where *gharries* fit to carry a large log are not procurable, and the roads perhaps muddy or through heavy sand. To move a clearing of say 5000 logs from the forest to the river, and over some miles of bad road, would be a work of immense expense if each log were rolled down singly, but the labour is infinitely lightened if every log is converted into a temporary rail for the others to travel on.

Beginning in the forest, roll up the logs so as to form a double line of rails, always placing the thick end of the log foremost; carry this through the centre of the clearing, or where the logs lie thickest; then construct branch lines from this at various angles, so as to reach to all parts of the clearing, and so many of these that the unemployed logs will not have to be rolled far to reach one of the lines.



On completion of this, roll the remaining logs on to the rails by means of a pair of stout saplings,

and along the rails to the end of the main line, where they are rolled off, and laid down in continuation of the line. The scattered logs having been all removed, begin at the ends of the branch lines, raising the last logs one after the other on to the rails, and rolling them away to the end of the main line, employing them all in their order to lengthen the line, until the river is reached.

On coming to an incline downwards, the logs would run away, and acquire an impetus that would probably throw them off the line to a considerable distance. To obviate this, place the rails close together down the incline, and turning the travelling logs round endways on coming to this point, slide them along the groove between the pairs of rails. A few short rollers will probably be necessary to slide the log along before it has acquired an impetus, but once set in motion it will glide along rapidly to the foot of the descent.

If there is an ascent steep enough to render it difficult to roll the log up from behind, take two ropes of 50 to 100 ft. in length, and securing these by means of grappling-hooks firmly driven into the butts of the rails ahead, bring the other ends back under the log and round over (*vide* the bottom line of rails in the last Plate), when the

coolies, taking hold of the free ends, walk forward with them, rolling the log after them.

This is the best way I know for getting a log uphill. In the colonies, heavy logs are moved in the forest in this manner by yoking a team of bullocks to each rope.

Moving timber out of the Hills.—If the timber is wanted at the foot of the hill, and the angle not more than 45°, and the surface free from rocky protuberances, the tree, on being barked and stripped of its branches, may be set in motion, butt foremost, and allowed to slide to the bottom. The tree should be left its entire length, as it will thus run much better and straighter than if cut up into logs, which are apt to wheel round and get caught and shaken. Of course, only straight timber can be worked out this way; and this being set in motion, will travel down an angle of 10°. At low angles, rollers are required to set the log in motion.

If the angle of incline is higher than 45° or the surface rugged, the timber would be shaken and damaged by this method, and it is better to expend labour in lowering it gradually. This is done by means of four stout ropes attached to grappling-hooks, two of which are fixed in the foremost end of the timber, and two at some distance from the other end. Strong hooks, about

a foot in length and two inch thickness, are required. The hooks being firmly driven into the timber, secure the two foremost ropes each round a tree on either side of the log, leaving 15 or 20 ft. slack for the log to run away with. The after ropes are also carried each round a tree, but instead of being made fast, they are drawn up nearly close, and one or two turns taken round the trees. A roller is next placed under the butt of the log, which is set in motion by rolling it from side to side, or dragged forward by picks driven into it. The men at the after ropes slack away gradually, until the foremost ropes stop the log, when the ropes are moved forward, and the process repeated until the bottom is reached. If the log is brought up on a declivity so steep that it would not stand while the ropes are being shifted, the hinder ropes are made fast, and hold it while the foremost are being shifted ahead. Six-inch rope is required for heavy timber, and is less likely to snap than chain.

In extensive hill forests, where the slope is not too great, timber is best transported by slides, which are roads cut in the face of the hill, at an angle of 8° to 15°. The timber above the slides is lowered in the manner above described,

laid lengthways along the outer edge of the road, and secured with pegs driven into the ground. On completion of this parapet, the remaining logs are lowered one by one into the slide, and set in motion with the assistance of rollers, when they shoot down like an arrow from a bow. At the close, the parapet logs are taken up one after the other, and shot down in the same manner.

Such slides are impracticable round sharp points or deep indentations, but it is sometimes possible to meet the latter difficulty by extending the slide sloping up the opposite hill. This stops the logs, which can then be turned round, and set in motion in the required direction.

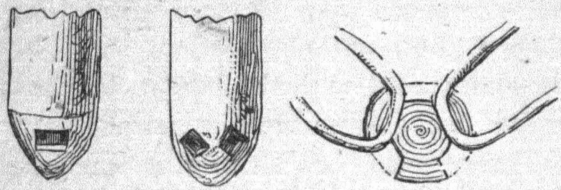
Snow-slides require little labour to construct. Timber will travel over these at an angle of only 5°, and may also be shot over the steepest declivities, covered with a good depth of snow, without danger. They are extensively employed in the Bavarian Alps.

Water transport.—In small rivulets, not more than 20 to 30 ft. wide, in the Black Forest, I have seen rafts of a thousand pine-trees rushing down at the rate of 6 to 10 miles an hour. The rivers are first cleared of the larger rock masses and impediments, and the water stored in reservoirs to admit of a flood being sent down when a raft is ready for despatch. Dams are also constructed

at intervals along the streams, and opened as the raft approaches.

These rafts are constructed in joints, each of which is composed of a number of timbers of uniform length, as many of these being bound together as will occupy nearly the whole width of the stream.

The logs are prepared for binding together by being holed at both ends. One hole at top, and one on each side below, is cut out with the axe or adze, and two to three-inch augurs used to connect the top hole with the two bottom ones.



Top. Bottom. Section with bands in their places.

The logs of each joint are then firmly lashed together with hazel rods 8 to 10 ft. long, and 4 to 6 in. girth at thickest, rendered tougher by a little roasting while green, and then twisted until the fibres partially separate, after which they are kept in water until required. Creepers are probably the best available bands in Northern India, canes in the South.

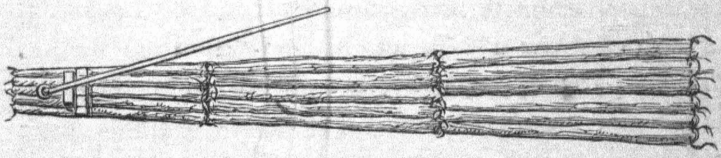
Each log, it will be observed, has two bands at

each end, one to lash it to the log on either side, and, after being thus lashed together, the free ends, of the bands serve to connect the several joints; but they are supplemented by two other bands passed through the holes for this purpose expressly. The holes, must thus always be large enough to admit of two bands being passed through them.

These bands are not as pliable as rope, and cannot be securely fastened without the aid of a good strong pick, the point of which is used for making a passage, as sailors use marling-spikes, and the hammer to tighten the knots by striking upon the bight.

Each joint is usually constructed separately on the bank, then launched and lashed to the joint in front of it.

The raft tapers to the front, the leading joint consisting of three or four saplings only of 6 to 8 in. diameter. This joint is made with great care, the fastenings being supplemented by a wooden pin passed through all the logs breadthways. From



near the point, also, a light spar extends back for some feet over the second joint, rising at such an

angle as to admit of its being breast-high behind. One or two men stand by this, and, by pressing it downwards, keep the nose from diving to the bottom after a sharp fall in the river. The principal attention is devoted to the fore part of the raft, for if this is kept clear and in mid-stream, which is effected by men armed with poles to guide it, the after joints require little attention. Even in sharp curves, if the fore part is kept clear, the after part will follow, although it may at times rise over the bank. The construction of the raft gives a flexibility which admits of this. Still it will sometimes happen that a raft is suddenly brought up, and if no provision were made for this, the after joints are in danger of snapping their bands, and rushing over the fore part. This is guarded against by men stationed on the penultimate joint, in which the centre log is a couple of feet shorter than the others. Lashed to the end of this log, and to the log on either side, is an upright beam, which ordinarily inclines forward at top, in which position it just grazes the bottom, but on a shock being felt forwards, or the word being passed, the beam is drawn into a more upright position, when its lower end strikes into the bottom and anchors the raft. On the passage from rapid to stiller water, too (*id est*), where the after part of the raft is in a stronger current than the fore part, the

beam is constantly employed to retard the progress of the after part, and prevent its overrunning the fore part.

In the Black Forest, I observed that the raftsmen simply struck their axes into this beam to get a hold of it, but it would probably be better for inexperienced men to have rope handles attached to it.

A number of spare bands are always taken to repair mishaps.

On arrival at the Plains, and before the river deepens or widens very considerably, the raft is anchored at the bank, and its construction altered, because, in its articulated form, the after part, no longer restrained within narrow limits, is liable to swing round and render the navigation unmanageable. The raft must now be made stiff, which is done by breaking up the after joints, and employing the logs by lashing them fore and aft the remaining joints; and if the river is very sinuous in its course, it may be necessary to break up each raft into two or three rafts.

The course is now less rapid, but also less dangerous and difficult, and if the timber is light and fuel obtainable at this stage, each raft may be laden with a considerable quantity.

The rendering our hill-streams navigable for rafts would generally prove a formidable under-

taking, and it is probable that, in the present state of our hill forests, the necessary outlay would hardly be justified, excepting, perhaps, in some tributary streams; but, sooner or later, it must be taken in hand, if we are ever to get a large revenue from our hill forests.

Some of our hill divisions represent an area of not less than 500 square miles, equal to 320,000 acres, and allowing that 100,000 acres only of this were untrammelled forest land, and capable of being clothed with timber, 30 cubic feet per acre per annum, or 3,000,000 cubic feet, is only a moderate out-turn, and quite within the capabilities of such a tract.*

Such a tract would be equal to five miles on either side of a river fifty miles in length, giving, say, with all its sinuosities, 100 miles of river to clear. Now a tax of an anna per cubic foot on 3,000,000 cubic feet would give 187,500 rupees, equal to the interest at 5 per cent. on a first outlay of 20 lacs, and leaving 87,500 for annual repairs; that is to say, 20,000 rupees per mile might be spent in bringing the river into order, and 875 rupees per mile per annum for maintaining it. But when we look at the short and shaken

* In Hanover, a forest area of 1,184,424 *morgen*, equal to about 840,000 acres, gives a yearly out-turn of 44,686,400 cubic feet, or over 50 cubic feet per acre.

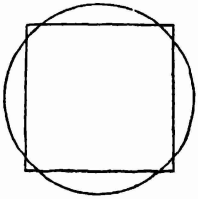
logs that now reach the Plains, and mark the higher rates realised for the few longer logs that sometimes reach the Plains safely, I think we may say confidently that any operations which would enable logs of 60 feet long to reach the market uninjured might be advantageously undertaken at a cost representing a tax of *four* annas per cubic foot. But the problem is not only to bring the logs down safely, but so cheaply as to create a market for the total annual increment.

The difficulties are unquestionably very great, and should not be undertaken except on carefully prepared estimates by qualified engineer officers; but it is not too much to assert that the successful administration of our forests hinges mainly on the facilities for timber transport.

CHAPTER VII.

MEASUREMENT OF TIMBER.

Prostrate logs.—The English method, and that usually adopted in this country to determine the cubic contents of a log, is to multiply the length by the square of the quarter girth at the middle. This method is erroneous with round timber, from the fact that the square of the quarter girth is less than the real area of section, which is determined by multiplying the square of the diameter by ·7854. In the accompanying diagram, the side of the square is the quarter girth of the circle, and it will be seen at a glance that the circle has a much greater superficies. The difference is, in fact, about 22 per cent., a log 12 inches in diameter having a superficies of 113 inches, while the square of the quarter girth gives 88½ inches only. This method is nevertheless a very fair one for measuring timber of not more than three feet girth, as the outer



slabs are of little value, but in logs of 8 to 12 ft. girth, such as are commonly sold by this Department, the loss to the seller is considerable. But it must be borne in mind that, as logs approach the four-sided form, the girth increases its proportion to the diameter, and the square of the quarter girth gives truer results than the method for determining the contents of cylindrical bodies, which method, if pursued with squared timber, would result in a loss to the seller of 22 per cent. But as the Department generally sells round logs, I would recommend that, when the diameter is over 18 inches, the contents should be determined by multiplying the square of the mean diameter by ·7854 and by the length. If the mean circumference is taken, then the square of this multiplied by ·07958.

There is yet another source of error and of consequent loss to the seller in this mode, the area of the middle of a tapering log being always less than the mean area. In ordinary timber sales the loss is trifling, as the logs sold rarely vary more than 6 inches in their extreme diameters, on which difference the loss is only 3 inches on the average area, or of one cubic foot in 48 feet of length. With 12 inches of difference in the extreme diameters, the loss is 12 inches on average area, or a cubic foot in 12 feet of length;

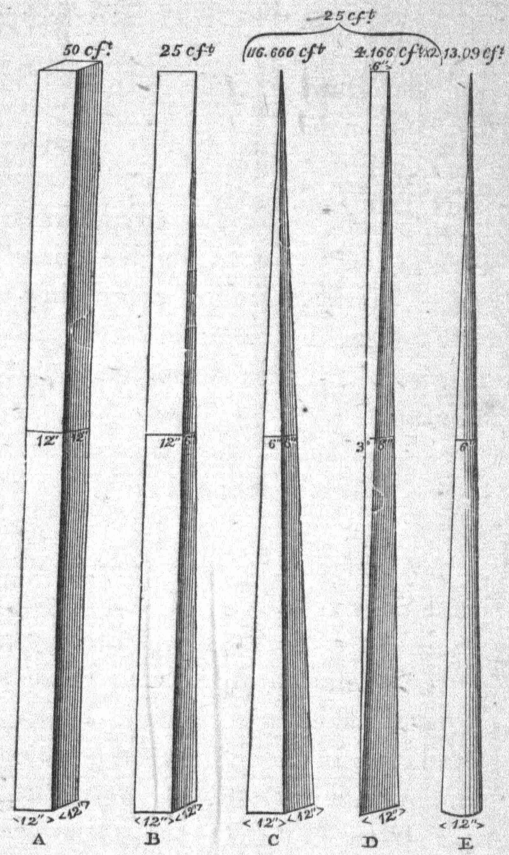
with 18 inches of difference, the loss is 27 inches on mean area, or 3 cubic feet in 16 feet of length, and so on.

But this difference, which is of little consequence in ordinary timber sales, would be a matter of very grave error in estimating the stock on a standing forest of tapering timber, such as pines or deodar—for here one fells typical trees, and measures the whole. In the accompanying diagram I have endeavoured to render this clear by an analysis of the formation of a tapering spar.

In this diagram, A is a beam 50 feet long, and with a side of 12 inches throughout, and consequently contains 50 cubic feet. B is a wedge reduced from the beam A, and contains 25 cubic feet. C is a pyramid reduced from the wedge B by the abstraction of the two pieces D, and contains $16\frac{2}{3}$ cubic feet. E is a cone reduced from the pyramid C by rounding off the edges, and its cubic contents are to those of the pyramid as ·7854 : 1. This relation of the cone to the pyramid being an established one, it will be simpler to employ the latter in looking at the problem.

Now suppose the pyramid C were the form of the sample trees felled to determine the cubic contents of the forest, and the officer were to proceed to determine its cubic contents in the usual manner, he would measure that tree in the

middle, and get $6 \times 6 = 36$ in., which, multiplied by the length, 50 ft., and reduced to feet, gives



$\frac{36 \times 50}{144} = 12\frac{1}{2}$ ft. But the absurdity of this method is apparent if we now cut the log in two pieces of

equal length, when the contents of the thicker piece, measured on this method, gives $\frac{9 \times 9 \times 25}{144} =$ $14\frac{1}{16}$ ft., or more than the whole tree measured in one piece.

I observe that Hopper, in his introduction to his Tables for Timber Measurement, gives a similar instance as an illustration of the peculiarity of timber; but the peculiarity is in the system of measurement, which is based on the erroneous assumption that the mean area of a pyramid or cone is at the middle, as it is in the wedge form B.

The common mathematical rule for finding the contents of a cone or pyramid is to multiply the length by one-third the area of base.

To get at the contents of the frustrum of a cone the rule is :—Add together the area of the greater and lesser ends, and the mean proportional area, and divide the sum by 3 for the mean area. (The mean proportional is obtained by multiplying the greater by the lesser diameter, and the product by ·7854.) For example, the lower half of the cone E is 25 feet long, with 12 in. greater, and 6 in. lesser diameter; then $\frac{12^2 + 6^2 + 12 \times 6 \times 25 \times \cdot 7854}{3 \times 144}$ $= 11\cdot45$, contents of the log.

By Hopper's method we have the square of the quarter girth (7^2); then $\frac{7^2 \times 25}{144} = 8\cdot50$, showing a

loss of 22 per cent. by taking the quarter girth, and nearly 4 per cent. by taking the area at the middle of the log.

Either of the three following methods may be substituted for the rule given above, and one of them should always be had recourse to when accuracy is required :—

Formula 1. To the square of the diameter at the middle, add one-twelfth the square of the difference of the extreme diameters, and multiply by ·7854 for the mean area, and by the length for the cubic contents. Thus, with the log above measured—

$$9^2 + \frac{(12-6)^2}{12} = 84 \times \cdot 7854 \times \frac{25}{144} = 11\cdot45.$$

Formula 2. From the mean of the squares of the two extremes deduct one-sixth the square of their difference, and multiply the product by ·7854 and by the length. Thus, proceeding with the same log—

$$\left(\frac{12^2+6^2}{2}\right) - \left(\frac{6^2}{6}\right) \times 25 \times \cdot 7854 = 11\cdot45.$$

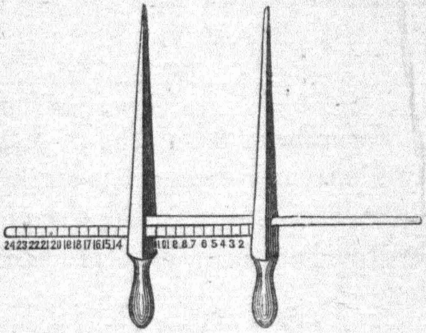
Formula 3. To the square of the mean add one-third the difference between it and the mean of the square of the extremes; multiply by ·7854 and by the length. Thus—

Square of the mean, 81. Mean of the squares of the extremes, $\frac{144+36}{2} = 90$; difference 9, one-third

of which added to 81 gives 84 mean area as before, and this multiplied by 25 for the length, and by ·7854, gives 11·45 also.

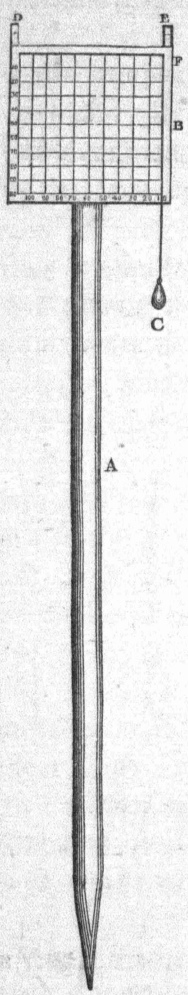
To measure standing timber, we require three factors, the diameter at base (usually taken at breast-high to avoid buttresses), the height of the tree, and the form figure of the tree, that is, its relation to a true cylinder.

The diameter at base is usually taken with a pair of *klappe*, one arm of which marks the width to which they open. This is much more expeditious and convenient than taking the girth, which can hardly be done well by one man, especially with large timber. Any country carpenter could make one, but care must be taken that the arms have little play in the sockets, otherwise the points open wider than the handles, and the measure chronicled will be below the true measure.



To measure the height of a tree, several instruments have been designed, one of the most con-

venient of which is that figured in the margin. A is a stock about 5 feet long, pointed for insertion in the ground, and mounted at top with a brass ferule, one side of which has a female screw. B is a board about 6 in. square, divided perpendicularly and horizontally into tenths, which ordinarily represent each 10 feet, and is fixed to the upright by a screw in the centre at the back. At the upper edge of the board are two brass uprights, one of which, D, is perforated with a pinhole; the other, E, is a frame across which a fine wire is stretched on the same parallel as the pinhole. At the right-hand corner, at top, F, is inserted a strong thread of silk, to which a small weight, C, is suspended.



Provided with this instrument, the operator selects a convenient spot from which there is a clear view of the top of the tree; this spot should be nearly on the same level as the tree stands, and about as far from it as the tree is high. Inserting the stock firmly and per-

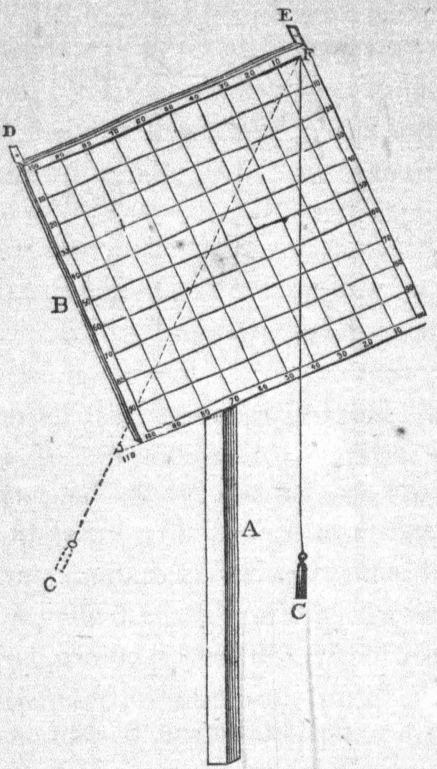
pendicularly into the ground, and screwing on the board, he next measures the distance from the base of the tree; he then returns to the instrument, and being cautious not to move the stock out of the perpendicular, he looks through the pinhole in the brass upright D, and turns the board round, elevating it in front, until the pinhole, the wire at E, and the top of the tree are in line. He now glances at the figure on the side, which corresponds with his distance from the tree, and looking along its line to the point at which the free swinging cord intersects it, reads off the height on the perpendicular line intersecting this point.

The board is once more placed horizontally, and the operator, glancing along it to the trunk of the tree, gets his assistant to mark the spot, the distance of which from the ground is added to the figures previously read off, which gives the height.

In the following diagram, if the distance from the tree be 20 feet, the height given is 9 feet; if 30 feet, 13 feet; if 50 feet, 21 feet; if 90 feet, 39 feet; to which measurements have to be added the height of the operator's eye above the base of the tree, as before explained.

If the instrument were elevated until the line fell as in the dotted line C, then at 20 feet dis-

tance the height would be 25 feet; at 40 feet distance, 46 feet; at 60 feet distance, 68 feet; at 90 feet distance, 100 feet; and if the distance were 100 feet, the height could not be read off on the board, but we could treat the 100 feet as 50 feet, when we find the line reads 56, and twice this, 112, would be the height, as is also chronicled by a dotted extension of the board.



These instruments might be made very cheaply at Roorkee, if a number were called for at once.

The form figure indicates the relation of the tree to a cylinder.

In the diagram, fig. 1 is the type of a pine-tree, and being a true cone, its relation to a cylinder whose

diameter is equal to its diameter at base is as 1 to 3, and its form figure $\frac{1}{3}$ or ·33; but as we take diameter at breast-high, the true form figure will range from ·35 to ·40.

Fig. 1.

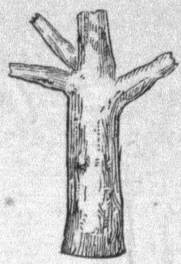


Fig. 2.

Fig. 2 is the extreme type of an oak grown in free space, and with its cubic contents equal to those of a cylinder; and trees ranging between these two extremes would be classed under the form figures ·40, ·50, &c., to 1·00.

With these data, height, diameter at base, and form figure, we arrive at the contents of a tree by multiplying the area at base by the height, and the product by the form figure. For example, to get at the contents of a tree 2 feet diameter at base, 70 feet high, and with a form figure of ·60, we say $2^2 \times \cdot 7854 \times 70 \times \cdot 60 = 132$ nearly, cubic contents of the tree. The form figure is usually based on the marketable contents of the tree, including branches, and is thus arrived at for a forest about to be valued :—

Fell half-a-dozen typical specimens, including those of greater and those of smaller diameters; then taking each tree separately, measure the trunk, or such part of it *as is a right geometrical figure*, and cut up and weigh all the crooked parts

and marketable branches, which, being converted into cubic feet, and added to the measured portion, the total is divided by the contents of the ideal cylinder, the length of which is equal to the total height of the tree, and the diameter equal to that of the tree at base. The quotient is the form figure, generally expressed by two decimals. For example:—If a tree 2 feet diameter at base and 90 feet high contains 120 cubic feet timber, we divide 120 by

$$2^2 \times \cdot 7854 \times 90 = 282\cdot 7)120\cdot 00(\cdot 42, \text{ the form figure.}$$

$$\begin{array}{r} 11308 \\ \hline 6920 \\ 5754 \end{array}$$

We have seen above that a true cone would be represented by the form figure ·33, but true cones are rarely found in the forest; the spar tapers irregularly, and specimen trunks should always be cut up into 10-feet lengths and measured separately. The form of all the sample trees being thus severally arrived at, their mean is taken as the form figure of that forest. While the operation is in hand, it is as well to determine the relative proportion of timber and fuel.

CHAPTER VIII.

TAKING STOCK.

THIS is the determination of the cubic contents of growing timber in a forest, and is arrived at with tolerable preciseness by measuring every tree with the aid of the three factors indicated in the last chapter, or approximately by determining the contents of a measured strip selected as a fair average.

If it is determined to proceed in this manner, viz., by actual measurement of every tree, or of every tree in a selected plot or strip, it will be convenient to operate in parties of four, two provided with *klappe* to take diameters, one with a book or sheet of paper to note them down, and one with an axe to mark the boundary trees as they are measured; unless it be a sample strip, when it is better to have the boundary trees marked at time of plotting it.

The book or paper is ruled with columns for various diameters. If a valuation survey is required, there should be a column for every advanc-

ing inch; but if the measurements are required only as the basis of a working-plan, each column may embrace two or three inches of difference, thus—

6	8	10	12	14	16	18	21	24	27	30	33	36
...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	..	...	..	...	...	..	...	..
...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...
Total	...	...	...	...	...	...	...	...	...	...	...	...

The site of operations having been selected, the party should commence with a strip of fifty to a hundred feet wide along one of the boundaries, the men with the *klappe* on either side, the writer in the middle, and the axeman in close attendance on the inner *klappe* man.

The party now marches straight forward; the *klappe* men grasp each tree in rotation, and read off the numbers in an audible voice; the writer makes a stroke in the corresponding column, and draws every fifth stroke diagonally across the other four for convenience of subsequent addition, and has ample leisure to look round him and see that no trees are missed. The axeman marks all the outer trees of the strip as they are measured. On reaching the opposite edge of the forest, the

party wheels round, and the barked trees of the last strip become the outer boundary of the second strip. This is work into which forest subordinates may be readily drilled; and if the forest area is vast, half-a-dozen such parties of four men may march abreast.

The diameters having been all taken, local peculiarities will enable the officer to determine whether a few typical trees may be selected as a general average of height of the whole, or whether these should be divided into classes according to girth. As a general rule, when the trees vary much in diameter, they should be divided into classes—6 to 12 in., 12 to 18 in., 18 to 24 in., 24 to 36 in.—and the height of half-a-dozen trees of each class determined; then the total number of trees in each class, multiplied by the height, area at base, and form figure, gives the cubic contents.

As a preparatory step to stock-taking, the forest should always be divided into well-defined and numbered blocks.

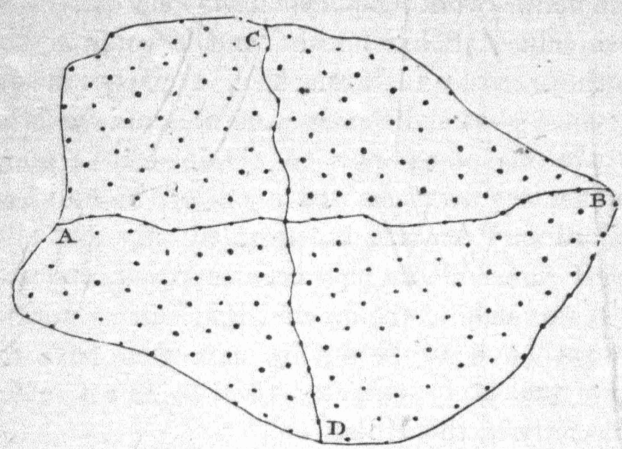
But although this operation is a perfectly simple one, it would take a large and well-organised party to get over 200 acres a day, devoting all their time to field-work; and as it is rarely possible to give more than 150 working days in the year to it, about 30,000 acres per annum may be set down as

the utmost that could be accomplished under one European officer, devoting his whole time to it—a rate at which some of our Divisions would take ten years to complete. We can hardly wait for systematic working-plans until one party shall have valued all our forests, and it would add very much to costs to form such a party in every province; but sufficiently accurate data for a basis of working-plans may be obtained in a simpler manner by every executive officer, in addition to his ordinary avocations, provided only that all the larger forest blocks have been surveyed, and a map to scale made of them; and this survey work will always be done better by men who have made surveying their specialty than by forest officers, especially in the Hills.

As a basis for this readier-found data, it may be observed, that when the forest consists of one class of tree only, or of trees similar in their habits of growth, the diameters of the stems (barring accidents from snowdrift or windfall, and irregularities caused by the woodman's axe) will bear a tolerably uniform ratio to the interspaces, and that at all ages of growth.

With a pair of callipers, a tape measure, and a notebook, two men could walk through a forest of eight or ten square miles in a day, taking the diameter of every tree *en route*, and measuring the

interspaces; and this, supplemented by a cross section, CD, would afford a good general average of the forest. Then adding all the diameters together in one column, and all interspaces together



in another, and taking the mean of each, we say, as the square of the mean interspace is to the square of the mean diameter × ·7854, so is 43,560 (number of square feet in an acre) to the ground area of timber per acre; and having the area of the forest, and taking the height of a few trees of different girths as averages, we are enabled to determine approximately the cubic contents of the block, and the proportion of trees of various girths.

It will be observed from the diagram that one does not proceed forward in a straight line, but

marches always upon the nearest tree in the general direction.

After some days at this work, it will generally be found that the proportion of tree diameter to ground area varies so little in forests of the same class, that the relation may be set down as a known quantity—say as 1^2 to 16^2 or 20^2 or 24^2; and having determined this relation, it is only necessary to take the diameters to determine the proportion of trees in each class, and the height for the cubic contents. Of course the form figure must be determined for this, as for the more precise method.

In this manner every Divisional officer might in two years get such a good general idea of the state of his growing stock as would afford a fair basis for a working-plan, and more precise stock-taking might be left until the specially-appointed valuation staff had leisure to take it up.

CHAPTER IX.

PERIOD OF FELLING.

TREES, like all other organisms, have their periods of growth, maturity and decay, and necessarily there is a period at which, varying in different trees, the annual increment has attained its highest point. Let us say that at sixty years an acre contains 2400 cubic feet timber, and increases 600 cubic feet in the next ten years; and 500 cubic feet in the second ten years, and we say it has passed its highest rate of increase at seventy to eighty years; but it has not yet passed its highest average.

At 60 years we have $\frac{2400}{60} = 40$ cubic feet per annum.

At 70 „ $\frac{2400 + 600}{70} = 42{\cdot}8$ „ „

At 80 „ $\frac{2400 + 600 + 500}{80} = 43{\cdot}7$ „ „

If it increase 800 cubic feet in the next twenty years, then—

$$\frac{2400 + 600 + 500 + 800}{100} = 43 \text{ cubic feet per annum.}$$

And we now say it has attained its highest average between eighty and a hundred years, and that that is

the length of rotation at which it would be desirable to cut it, unless large timber of the class is worth more per cubic foot than small timber; and this being ordinarily the case, the timber should be allowed to stand until the annual falling off in increment is barely compensated by the increased money value. Moreover, between the sixtieth and the hundred and twentieth year we may count on being able to thin out to the extent of one-fifth the quantity of stock at final clearing without detriment to ultimate results.

German forest literature abounds in elaborate tables of the growth at various stages of every description of tree in the German forests, but these would be useless as a basis for calculating the rate of increment in our Indian forests, especially in the Plains, where the growth during the first period of twenty years is vastly in excess of anything known in Europe. The corresponding statistics concerning Indian trees must be studied by practical research in the forest itself.

The following tables, giving the cubic contents of an oak, a beech, and a Scotch fir forest at their several stages, may be taken as indicating the general ratio of increase of each class within itself; but being compiled by three different authorities, they must not be taken as indicating the relative growth of the three classes.

Pfeil—Scotch Fir			Grebe—Beech.			Pressler—Oak		
Age.	Cubic contents.	Annual yield.	Age	Cubic contents.	Annual yield	Age	Cubic contents	Annual yield
10	280 ft.	28	10	60 ft.	6	10	200 ft.	20
20	640	32	20	500	25	20	700	35
30	1000	33	30	1300	43	30	1200	40
40	1500	37·5	40	2200	55	40	1700	42
50	2000	40	50	3100	62	50	2400	48
60	2400	40	60	4100	68	60	3100	51
70	2800	40	70	5000	71	70	3800	54
80	3100	38·7	80	5700	71	80	4700	58
90	3400	37 9	90	6400	71	90	5500	61
100	3700	37	100	7000	70	100	6400	64
110	3900	35·4	110	7500	68	110	7200	65
120	4100	34	120	7900	66	120	8100	67
						130	8900	68
			Total of thinnings over the whole period, 2900 cubic feet.			140	9700	69
						150	10400	69
						160	11100	69
						200	13400	67
						Thinnings over the whole period varying from 25 per cent. to 50 per cent. of final cuttings.		

The cubic contents here given are per Austrian *joch*, which is 6173 square yards, or a little more than an acre and a quarter.

Now it is very evident from these tables that to cut the oak before it reached a hundred years, or the beech before it reached seventy years, would be to lower the annual revenue of the forest below its capabilities; but on examining the pine, we find that to cut it at fifty years would secure as high a yield per annum as is attained at any subsequent stage, and 25 per cent. more than is realised on a 120

years' rotation, which latter is indeed but a trifle higher than is to be got from a twenty years' rotation. What, then, is the inducement to protract the period?

This is readily rendered intelligible. At fifty years we may suppose there were 125 trees, 60 feet high and a foot diameter at breast-high, giving 2000 cubic feet; at 120 years we may estimate 75 trees, a foot and a half diameter at breast-high and 90 feet high, giving 4000 cubic feet. (This is taking ·33 as the form figure.)

Now these 125 trees would taper to 6 inches diameter at 30 feet, leaving 125 spars, 30 feet long and 6 inches diameter at base, unsaleable as timber, while the 75 trees in the longer rotation would only taper to 6 inches at 60 feet, leaving only 75 spars, 30 feet long and 6 inches at base, as unsaleable. This would leave 325 cubic feet waste, or about 15 per cent. on the 2000 cubic feet, and 187 cubic feet, or a little less than 5 per cent. on the 4000 cubic feet.

Moreover, between the 50th and 120th years, 50 trees, equal approximately to 1500 cubic feet, have been thinned out.

On the fifty years' rotation the saleable timber is 2000 − 325 = 1675, or 33 cubic feet per annum, and on the 120 years' rotation, 4000 − 187 = 3813 + 1500 for thinnings, giving a total of 5313 or 44.

cubic feet per annum, or 33 per cent. in favour of the longer period in mere quantity, to say nothing of the higher price realisable from 60-feet spars in comparison with 30-feet spars.

From this it will be seen that an important element in forest administration is a careful determination of the period of felling which will give the highest pecuniary results.

But forest increment is a science of itself, and to lay down instructions for determining the relative growth of trees at various stages would involve a certain amount of technicality foreign to the purpose of this little work. Pressler's *Forstzuwachs-Kunde*, published by Waldemar Türk, Dresden, might be advantageously consulted by those having an acquaintance with German.

CHAPTER X.

COPPICE OR NIEDERWALD.

THE foregoing remarks refer especially to timber forests, but all forests are not grown for timber. If we were to convert all the waste lands in the plains of India into forest in this generation, I have no doubt that a century hence there would be a vast improvement in the structure of native houses and in their internal arrangements, and that there would be men ready and willing to extol the wisdom and foresight of their ancestors; but these appreciative murmurs, floating idly over the graves of the deaf dead, would hardly compensate them for the labours of which they never reaped the reward.

In the last chapter I deprecated the reduction of the capabilities of our forests by premature felling and inattention to reproduction; for a very proper sentiment lies at the bottom of the motive which prompts us to leave those who come immediately after us no occasion to tax us with

spoiling a property in which we had only a life-interest, and which was ours only in trust for future generations. But to tax the present generation for benefits to be reaped a century hence is to sacrifice justice to the present for generosity to the future. Hence I would not advocate the formation of new timber forests on a large scale, except in so far as this can be done by a fair tax on a liberal present forest revenue. Even if we were entirely to identify the present with the future, my rough calculations lead me to assume that, to grow timber taking a hundred years to reach maturity, the forest would be so heavily weighted by compound interest accumulating on the first outlay, that it would be nearly two hundred years before it would show a balance-sheet superior to that of a coppice wood in a locality where there was a good demand for fuel and *bullahs*.

In the face of a newly-developed demand for timber in a country in which forests did not exist, it would be a matter of very questionable prudence to commence growing timber on a large scale, at least if anything approaching a hundred years was required for it to come to maturity; for, under English rule, material progress would hardly wait with folded hands while the timber was growing, but would rather turn to some substitute, with

which the timber when mature might be unable to compete.

But to grow forests to meet an increased demand for fuel is another matter. On the plains of India first-class wood-fuel can be produced in ten years; and although, even while this is growing, the railways, which first provoked the demand, may be driven to resort to imported coal, there is every probability of wood-fuel again successfully competing with it; and even if it fail, the rapid extension of agriculture under a settled government is fast reducing the old area of fuel wastes, leading to a rapidly-increased demand for fuel and poles for domestic purposes. By raising fuel-plantations systematically and economically, we can set free jungle-lands for agriculture, while increasing the fuel production.

The question of the growth and administration of fuel-plantations is thus to some extent a matter *sui generis*, and the considerations which guide us in their administration somewhat different from those which guide us in the administration of forest proper.

The first point is the selection of trees which coppice freely. Among Northern Indian trees, the sissoo, mulberry, and large bér (Zizyphus jujuba) take first rank: the sal coppices as freely, and is an excellent fuel wood. These should be

sown in lines at 7 to 10 feet apart, or, if planted, may be put in at 5 to 6 feet apart.

The period of felling is not, as in timber forests, determined by the period of highest increment, but by the period at which the stumps send out the most vigorous shoots, which is generally when they are from 4 to 9 inches diameter.

The bér will coppice as vigorously from larger stumps, but the shoots have not as good a hold on the stump; the stump is more liable to decay; the fuel requires to be split; and after the first clearing, the shoots will probably attain their highest capacity for increment at 6 to 8 inches diameter.

The fellings should never be performed with the saw, as shoots from sawn stamps are liable to windfall; nor should the top of the stump be left cup-shaped, or water will lodge on it, and cause early decay. The stems should be cut nearly through from one side, a small notch only being made at the back to prevent splitting.

Coppice stems grow much quicker than seedling stems in their first stages, but retardation of growth sets in sooner. The following table gives the average proportion of oak and beech seedling and coppice stems for sixty years, by which it will be seen that

the coppice takes the lead for thirty years, when it rapidly drops behind.

YEARS.	SEEDLING.	COPPICE.
10	2	2
20	4	6
30	6½	9
40	9½	11
50	12½	12
60	16½	13

The period of coppice-rotation in Germany is usually thirty years, but the above-mentioned Indian trees will give better results in ten years than beech or oak in thirty.

Coppice should be grown tolerably thick, and blanks caused by decayed stumps immediately re-stocked; the stems will thus grow tall and straight, and both yield more fuel, and give a better proportion of poles, than if the stocks were more scattered.

CHAPTER XI.

FORESTS OF TREES OF VARIOUS AGES (MITTELWALD).

THE German *Mittelwald*, or mixed forest of timber and coppice, will be best understood by regarding it as an old coppice in which a few stems per acre have been spared at every cutting, until, in process of time, it contains trees of all ages, from timber to coppice shoots and seedlings; and at every coppice clearing a few selected stems being left, a corresponding number of older trees are taken out.

The theory of this system is a very pretty one. It rests upon the assumption that a dozen or twenty trees to the acre, left at the first cutting, would neither perceptibly affect the yield of coppice, nor would they shade the ground so as appreciably to affect the yield at the second cutting, while it is understood that the trees make more wood in the later than in the first stages, and are also growing to a better class of wood.

Practically the system is not so satisfactory.

The reserved stems, on being left standing alone, immediately send out strong lateral branches; they never rise to the height desirable in timber trees; and at any subsequent period of growth they are found occupying more ground space than would be occupied by a tree of equal cubic contents in a timber forest. After a few rotations there is a very marked depreciation in yield of coppice wood, while the forest, regarded as a timber forest, is in a hopelessly unsatisfactory condition.

I visited many *Mittelwald* forests in Germany, and found them very instructive as indicating what to avoid; but they were mostly private forests, and the forest officers with whom I visited them generally agreed with me that their unsatisfactory state was mainly due to leaving more stems at every felling than was consistent with the ideal theory of a mixed forest.

The cubic contents of each felling were generally on a par with the yield of pure coppice, and the money value somewhat higher; and although the system has been almost entirely discarded in State forests, I am not quite sure that it might not be advantageously introduced into our coppice plantations, provided we keep in view the maintenance of the coppice yield, and do not leave too many stems for timber.

To form a *Mittelwald*, one proceeds in precisely the same way as for coppice up to the first felling, when, instead of clearing all off, twenty selected stems to the acre should be left as nearly as possible at uniform distances of 45 to 50 feet apart. No more stems should be left at the second period, as these would be only coppice shoots, which would never grow to timber. At the third period there would be seedlings from the first reserve, and of these, six per acre might be reserved, a corresponding number of the first reserve being cut out to make room for them, and the process repeated at every felling, the six stems taken out being not trees of uniform age, but one or two of the reserves of each period.

Even with this moderate number of reserved stems there would soon be an appreciable diminution in the yield of fuel, but I believe the timber yield would more than compensate for it.

CHAPTER XII.

FELLING BY SELECTION (PLÄNTERBETRIEB).

THIS is the primitive system of working forests in all countries. In its ruder form, the forester proceeds without method, going into the forest and selecting such timber as suits him, irrespective of the relation of its cubic contents to the forest increment. Reduced to system, it implies a condition of the forest in which every part is covered with trees of each period of growth in just proportion, so that with say a rotation of a hundred years, if all the trees of full age be taken out in any one year, there will be a corresponding number which will reach maturity the following year. Among the drawbacks of this system, a very important one is the large area over which operations range, and the consequent difficulty of supervision. This is to some extent met by dividing the forest into twenty equal blocks, and cutting the required number of trees in each block annually. The introduction of this modification upsets the regularity of yield

to some extent. In the first year, we can only get the just number of trees by felling all from eighty to a hundred years; in the second year, the trees are from eighty-one to a hundred and one years, and so on to the twentieth year, when the last block gives the required number of trees at from a hundred to a hundred and twenty years; and in all subsequent rotations this irregularity will be perpetuated. And even on this modified system the area under treatment annually is much greater than it would be when felling was conducted on rotation of area.

In gregarious forests this system of working has all the disadvantages of *Mittelwald* forests, and perhaps in an aggravated measure; for although in the *Mittelwald* the trees are generally found so near together that the coppice has no chance in the struggle, the trees themselves do not generally interfere with each other; while in the *Plänterwald*, the whole forest being stocked with trees in various stages of growth, all mixed promiscuously, every growing tree is oppressed by a stronger neighbour, and forming lateral branches on its free side, overpowers and checks the development of its next younger neighbour. On the other hand, it is claimed for this system that, in the final period, it affords light-loving trees that free space which they cannot get in close forests; that in

practice it is possible to modify the system by leaving the trees of each stage of growth in larger or smaller clumps, instead of singly, and that, when it is desired, scattered trees may be left to attain the largest possible dimensions with little prejudice to the young crop below.

The annual outcome, *cæteris paribus*, is said to be barely two-thirds of the outcome from timber forests worked by rotation of area; and, with the progress of scientific forestry in Germany within the last century, the method has been to a great extent abandoned in State forests, but it still prevails in private forests, the proprietors or managers of which attach little weight to the objections against their method, and smile complacently upon the new system.

This system of felling by selection has been spoken of very favourably for India, and there can be little doubt that it is the method best adapted to lofty mountain ranges, the steep slopes of which, if laid bare area by area, would be exposed to erosion by avalanches, landslips, &c. In mixed forests, too, worked mainly for one valuable class of timber, which is not the preponderating class in the forest, the system of felling by selection could not generally be departed from without felling a great deal of immature timber in course of transition; but even here, if the conditions were such that it were pos-

sible to subdivide the Division into blocks, that the bulk of the teak or other valuable timber in each block should be of approximately uniform age, the disadvantages of perpetuating the system of felling by selection should not be lost sight of. First, it spreads operations over immense areas, a matter of far greater importance in our immense Indian divisions than in a German forest charge, which rarely exceeds five thousand acres. Secondly, although favourable to the growth of large timber, it is not favourable to the growth of tall timber. Thirdly, mature trees cannot be felled without damage to younger trees. Further, the collection of scattered logs over the whole forest area, and working them out singly, is not only expensive and difficult, but causes incalculable damage to the young seedlings; and, finally, there is a difficulty in so apportioning the fellings to the increment, as to maintain permanently the *status quo* of the forest; and should the working-plan be based on estimates above the mark, its provisions cannot be carried out save at the cost of rapid, although at first imperceptible, degeneration both of standing crop and rate of increment.

CHAPTER XIII.

FELLING BY ROTATION OF AREA.

THIS is the German forester's attained ideal of methodical treatment, and is especially suited to forests of gregarious trees. The forest is divided into blocks as many in number as there are years in the rotation. These blocks are uniform in size, or vary in area with the capabilities of the soil, so as to equalise the yield. Large forests are generally cut up into primary divisions, rarely exceeding five thousand acres, and each of these primary divisions subdivided into annual blocks.

These divisions are each in charge of a competent officer; and if it were determined to work up any of our forests to this regular system of rotation, it would be a matter for consideration at the outset whether the number of primary divisions should be based on the numerical force of the existing staff, or upon a probable increase to their numbers. If our forest divisions were now divided into subcharges of fifty thousand or a hundred thousand acres each, and each of these subdivisions divided into

a series of annual blocks, it would hardly be possible at any future time to effect a further subdivision, especially if the blocks were situated in the order of their numbers; but the difficulty would be trifling if there were a fortuitous irregularity in the position of the blocks with relation to their numbers, which would render it possible to divide the division into two equal parts, in each of which there would be a corresponding number of blocks of all ages; but if the blocks follow each other in the order in which they come to the axe, we might not be able to cut the division into two parts without getting all timber above middle age in the one part, and all below middle age in the other. This objection does not hold in a forest worked on the system of felling by selection; such a forest, however subdivided, would still have trees of all ages in each subdivision.

Recurring to the system of felling by rotation of area, if the period of rotation were fixed at a hundred years, each forest or primary division would be divided into a hundred blocks, and if planting were resorted to for reproduction, one block would be felled every year; and necessarily, after the first rotation, each block would come to the axe at an uniform age of a hundred years; and if in the course of the rotation one or more blocks were laid low, or so damaged as materially to affect the

promise of the outcome, it is frequently advisable to complete the clearing of such block or blocks, and provide for re-stocking it at once. Its place in the next rotation would probably have to be altered, and the loss in outcome be spread over the rest of the rotation by a rateable reduction of felling in each block.

If natural reproduction is relied on, we cannot then effect a clean sweep of one block per annum, but must begin by thinning out the older blocks in that gradual manner prescribed in the chapter on natural reproduction; but after we have got as many years into the rotation as are allowed from the first thinning to foster germination to the final clearing, we have always one block to be finally cleared annually—one block in which we make the first thinning, and another or others in which we make the second and intermediate thinnings, to admit light and foster the growth of the young crop.

This necessitates felling operations being spread over a large area; and, as a general rule, when felling by rotation of area is the system, artificial planting is resorted to for reproduction.

On this system trees have only to struggle with those of their own age; they lead each other up tall and straight; periodical thinnings afford the necessary space for lateral development; and the

result is an out-turn equal to the full capabilities of the soil. Moreover, the operations of planting, thinning, and felling are all carried on in well-defined areas only, and younger trees are not damaged by the older being felled on and worked out over them. This renders supervision easy and effective, and, guided by the working-plan, the controlling officer can see at a glance whether the work returns of the year are in accordance with its provisions.

CHAPTER XIV.

TIMBER FOREST WITH COPPICE.

THIS is a further modification of the last system, resorted to when it is desired to secure heavier timber than is to be obtained from close forest, by which term is understood a forest in which the branches meet overhead. The forest having been subjected to the ordinary thinning until the trees have attained nearly their full height, is then subjected to a sharp thinning to the extent of 50 or even 75 per cent. The remaining trees, bathing in the full sunlight, and no longer crowding each other, soon develop a broad spreading crown, with proportionate increase in girth of trunk. And provision having previously been made to guard against the trees being drawn up too rapidly for their strength, they will now develop that ample girth which they would have attained had they grown from the first in free space, with the additional advantage of combining height and straightness with great girth.

Oaks thus grown for large timber are sometimes allowed to stand for another hundred years after the last thinning; and to shade and utilise the vacant ground, and preserve to the soil all its properties as forest soil, the whole area is planted with an under-crop, usually treated as coppice; or the coppice shoots of the felled trees are allowed to occupy the ground, and are cut over periodically for their bark; but when the trees are intended to stand for another hundred years or more, the soil is frequently covered with beech or pine, which are grown for timber, and on their reaching maturity, all are felled together.

CHAPTER XV.

TRANSITION FROM LOWER TO HIGHER FOREST CONDITIONS.

It is perhaps somewhat arbitrary to class a systematically worked coppice as a low condition of forest, especially when, as sometimes happens, it is the condition best suited to local requirements; but, nevertheless, as there is a gradually increasing scale of outcome from the coppice to the high timber forest, the classification of the various conditions into higher and lower appears legitimate.

As we have already seen, the transition from a young coppice to a forest of trees of mixed ages is easy and natural; we require only to spare a few seedlings at each felling, until we have the required proportion of high timber, when we can supplement the yield of each coppice clearance by felling with it a few older stems of various ages, and leaving a corresponding number of seedlings to take their place.

The transition from the forest of trees of various

ages to a timber forest worked by selection is more a change of system than of condition. For both systems we require a forest stocked with trees of all ages, from the seedling to the mature tree; but while on the one system we cut out some trees of all ages with every coppice rotation, on the other, we cut out annually those trees only which arrive at maturity. But to work a forest methodically, and with uniformity of annual yield, on the system of selection, it is important to determine in how far the areas of trees of each stage of growth are in just relation throughout; and in the case of great irregularity or preponderance of area of trees of any one stage, fellings should be arranged with an eye to their adjustment. The trees should be classed into periods of growth, and supposing we fix these periods at say twenty years, and the rotation at a hundred years, then one-fifth of the area should be occupied with trees of each period. With trees of all ages growing promiscuously together, it would be difficult to estimate the relative area of each by ground measurement, but by determining how many trees of each period will flourish on an acre, we know that in the present case we require one-fifth of the determined number of each period. Thus, supposing a forest of such trees as would stand at fifty to the acre in the fifth period

(80–100 years), we should probably find that the proportion in which they would stand to the acre at all periods would be somewhat as follows :—

At 1st	period,	1– 20	years,	800
„ 2d	„	20– 40	„	400
„ 3d	„	40– 60	„	200
„ 4th	„	60– 80	„	100
„ 5th	„	80–100	„	50

And in a forest worked by selection on a hundred years' rotation, we should require an average of approximately one-fifth of these numbers for each period to the acre.

If there are no blocks of trees of uniform ages at hand to afford data for fixing the number which an acre will carry, we arrive at it easily by measuring the spread of the branches of a typical tree of each period, and dividing the square of the spread in feet into 43,560, the number of square feet in an acre. For instance, if the spread of the branches were 30 feet, then $43{,}560 \div 30^2 = 48$, the number of trees of that spread which would stand on the acre without undue crowding.

The average increment of such a forest is approximately ascertainable, and the timber to be felled annually should be limited to such annual increment; for if trees of the older periods are in excess, and we keep cutting out all the mature timber, we

shall by and by find it impossible to maintain the outcome.

The transition from any of the afore-named conditions to such a condition as will enable us to work the forest by rotation of area, requires much more thought; the possible variation of conditions extends over a wide range, and every such variation requires a more or less special treatment. The general idea to be kept in mind is that of such a gradual transition as will admit of the end being attained by the sacrifice of as little present revenue as needs be; but improvement of system is a future gain, which must be paid for with a present price.

TRANSITION FROM COPPICE.

In the chapter on coppice it was seen that, during the first thirty years of its growth in Europe, the yield is greater than from seedling stems, but that after that period the latter take the lead, increasing rapidly in annual production, while in the coppice there is a rapid falling off, the increment becoming almost imperceptible at sixty to seventy years. But this is not necessarily true of India; and although we want data for determining the comparative rates of growth of seedling and coppice stems at all ages, there is ample data to support the conclusion that both sal and teak coppice will grow into good-sized timber; but,

unless the coppice has been cut off close to the ground, there is so commonly an element of decay developing itself at the point at which the new shoot encloses the old stem, that we could hardly count with confidence on raising really first-class timber by laying up coppice. But if it were determined to convert a coppice into timber forest in a Division in which there was no officer practically familiar with planting, the forest might be divided into as many blocks as there are years in the contemplated rotation, and one of these blocks be laid up annually, the remainder being worked for coppice as before. There would be of course an ever-increasing reduction in yield for the first few years, but this would subsequently be to a great extent compensated for by the yield of thinnings from the reserved blocks, and at the end of the period the forest would be cut over as timber forest.

This of course assumes that the coppice is a tall-growing wood, valuable as timber; but if this is not the case, or it is wished to introduce a better class of timber, planting must be resorted to. After the annual clearance, the block intended to be laid up should be planted with strong plants from 3 to 6 feet high, and at distances of 15 to 20 feet apart. The coppice may be allowed to grow with them, and be cut over as before,

as long as it is worth cutting, care being taken during the first few years to cut out shoots which threaten to domineer over or crowd the young trees.

In substitution of this method, we may plant the trees more closely, and keep down the coppice shoots until the young trees shall have domineered over them; and this would be the better course if the coppice is not straight-growing; or, better still, clear the ground entirely, if the stumps will pay cost of removal; but when there is no great demand for fuel, it will be cheaper to keep down the shoots.

The possibility of stocking each block in the order of its geographical position will depend upon the arrangement of the blocks in the coppice rotation; but if much stress is laid on it, it can be provided for at the trifling sacrifice of clearing the required block annually, irrespectively of whether it is mature coppice or not.

TRANSITION FROM FORESTS OF MIXED COPPICE AND TIMBER.

This is hardly a known condition in Indian forests. The method of its conversion into timber forest would be by the laying up of one block annually as with coppice, felling all the older trees from three feet girth upwards, fostering the young

seedlings by cutting out such coppice shoots as crowd them, and planting the bare spots. The block being now laid up, subsequent thinnings would be generally confined to coppice stems until these were all removed.

TRANSITION FROM THE SYSTEM OF FELLING BY SELECTION (PLÄNTERBETRIEB) TO THAT OF FELLING BY ROTATION OF AREA.

In prescribing rules for such a conversion of system, the European forest officer would naturally proceed on the assumption that the forest in which the change of method was to be effected bore some approach to the ideal condition of a just proportion of timber at maturity, and a just proportion of timber at every stage of growth. In dealing with such an ideal forest, the system of rotation of area might be adhered to during a great part of the first rotation. The trees felled would not be of uniform age, and the admissibility of the system would depend to some extent upon the prudence of felling more or less immature timber.

There are great possibilities of variety in the details of treatment with a view to such a transition, but a single instance will be sufficient to indicate the general principle.

Let us suppose a forest in which, if the trees

were of uniform age, they would at maturity—say at a hundred years—stand at fifty to the acre, but which, having hitherto been worked on the system of felling by selection, is now stocked with tolerable uniformity in something like the following proportion per acre throughout:—

Trees from	80–100	years,	10
„ „	60– 80	„	20
„ „	40– 60	„	40
„ „	20– 40	„	80
„ „	20	„	160

Now, if we divide the forest into say five blocks, ABCDE, and begin by laying up E for twenty years, treating ABCD as before, we sacrifice one-fifth of our income for that period (supposing, of course, that the forest had been hitherto worked up to its full capabilities). At its conclusion, E, having been properly thinned of all its small stuff during the period, will have been reduced to sixty or eighty trees per acre, varying from sixty to 120 years old. Now lay BCD up, and occupying the first five of the second twenty years in cutting out the large timber from A, we next turn to E, cut out the oldest trees in the next five years, the then oldest in the following five, and clear off in the last five of the period.

In this manner we avoid felling any timber under seventy-five years old; and getting a proportion at 120 years, the yield of this second period of twenty

years will probably be fully as high as in any similar period before conversion.

In the third period, the first five years would be occupied in selecting timber from A, which would then be laid up, and the next fifteen in clearing off D (taking the oldest trees first), with similar results to the previous twenty years.

We have now behind us D, covered with seedlings under twenty years, E with trees from twenty to forty years, and before us CBA, the two former of which carry timber from sixty to 120 years, and the latter from seedlings to eighty years; and taking C in hand, and cutting out the oldest trees first, we are able to clear the last at from seventy-five to eighty years old.

B being similarly treated in the next twenty years, the trees would be cut out at from ninety-five to 140 years old.

Finally, A, being similarly treated, would give trees from seventy-five to 120 years.

At the expiration of this period, we should have five blocks, in each of which there is a gradation of twenty years in age; but to complete the transition we want a hundred blocks in which the gradation is by annual steps; and we may not be able to divide any of these five blocks into twentieth parts, and secure anything like a yearly gradation of age in the blocks.

We have now the choice of spreading twenty years over each block, and felling the oldest trees first, which would be the introduction of a modified system of felling by selection in restricted areas, or of dividing each block into twentieths; and felling by rotation of area; and throughout the whole second rotation, instead of cutting at the uniform age of 100 years, we should have to cut trees varying from eighty to 120 years.

It will be gathered from this that the change of system is not a matter to be effected in a day, and should not lightly be resorted to at a great sacrifice of present revenue, even where the ultimate benefit is beyond question.

Throughout this example it has been assumed that reproduction is ensured either by planting or by thinning out gradually the timber to be felled, so as to foster natural reproduction, and that the blocks laid up were thinned where necessary, and principally by removal of trees under forty years old only.

But Indian forests, although they may have hitherto been worked on the system of felling by selection, will rarely be found in the state above pictured. Instead of having trees of all ages in due proportion springing side by side from an uniform undergrowth of seedlings, we find more generally that they consist of irregular blocks, in

each of which, if the timber be not exactly of uniform age throughout, trees of approximately uniform age will nevertheless preponderate.

Here the groundwork of the operation would be the division into blocks, and the classification of the areas of trees of the preponderating age of each block above or below their true place in the rotation; and the amount of departure from a just proportion of trees of all ages would be rectified in the course of the first rotation by felling a greater or less area above or below the age fixed as the length of the rotation.

Let us suppose, for example, that stock has been taken of a forest of 120,000 acres in extent, the proper period of rotation being fixed as 120 years, and that the returns per area, based on the preponderating trees of each block, are as follows:—

1st Period. 1-20 yrs	2d Period. 20-40 yrs.	3d Period. 40-60 yrs.	4th Period. 60-80 yrs.	5th Period. 80-100 yrs.	6th Period. 100-120 yrs.
Area in acres.	Area in acres.	Area in acres.	Area in acres.	Area in acres.	Area in acres.
10,000	50,000	35,000	15,000	10,000	...
And we want 20,000	20,000	20,000	20,000	20,000	20,000

Now, in the first period, having only 10,000 acres, we supplement it with 10,000 of the second period, in which we shall then have 40,000, one

half of which is allowed to stand as second period, and the other half carried to the third period. Of the 35,000 acres in the third period, we carry 20,000 acres to the fourth period; and the remaining 15,000 acres, with 5000 acres of the fourth period, being carried to the fifth period, we have left 10,000 acres of the fourth period and 10,000 acres of the fifth period to carry to the sixth period.

Having thus arranged the area in classes, it is evident that we cannot commence cutting at once without cutting immature timber for the next eighty years, by which course we should lower the money value of the increment, which is ordinarily highest in the last twenty years of the rotation; and unless immature timber were in fair demand, yielding a good profit, it would be desirable to give such a forest rest for a time.

Let us see now what would be the result of laying it up for twenty years—

	80–100 yrs.	100–120 yrs.	120–140 yrs.	140–160 yrs.
	Acres.	Acres.	Acres	Acres.
In the 1st period we should then have *	10,000	10,000	...	...
,, 2d ,, ,,	15,000	5,000	...	...
,, 3d ,, ,,	...	20,000	...	...
,, 4th ,, ,,	...	20,000	...	..
,, 5th ,, ,,	. .	..	20,000	.
,, 6th ,, ,,	...	...	10,000	10,000

* By cutting out the oldest first, we should guard against cutting any under a hundred years old.

And by this arrangement we should cut only the first 25,000 acres below maturity, and the last 40,000 acres above the recognised period of maturity, which may or may not be a disadvantage, according to the correctness of the data on which the period of rotation has been fixed.

If the preponderance of area had been of trees of the fourth and fifth periods, instead of the second and third periods, and the desirability of preserving each block to maturity fully recognised, the whole area carrying timber saleable at a profit might be sharply thinned through during the twenty years of rest, without prejudice to the ultimate crop, especially with deciduous trees, but only in the event of the forest being fully stocked; for, if fellings had already been so excessive, that, supplemented by fires which destroyed their seedlings, grass and rank undergrowth had got possession of the forest floor, our care should be to leave every tree until the branches had again closed, that the undergrowth might be destroyed, and the forest floor again fitted for tree reproduction. No prejudicial undergrowth can exist in a close forest.

It need hardly be pointed out that, as the trees in each block vary twenty years in age, it will generally be desirable to cut out the oldest first, by which means all are felled at an uniform age;

but if it is intended to work by rotation of annual blocks with artificial reproduction, the blocks may be each divided into twentieths, classed according to the age of the preponderating trees of each subdivision, and felled as they are classed; but if it were intended to trust to natural reproduction, the division into annual blocks would scarcely result in concentrating operations more than the modified system of *Plänterbetrieb* indicated in the last example—that is, a *Plänterbetrieb* in which the trees of each block vary only twenty years in age. The choice between these rival systems would depend generally on the rate of growth of the young crop. With timber like sissoo, the seedlings of which in favourable conditions reach a height of from two to five feet the first year, the rotation of area would have the preference, as the block opened for light the first year might be cleared off the second, and operations be always concentrated on two blocks; but with slower growing seedlings, in which it is necessary to thin out slowly, and at intervals of three or four years, operations would be spread over nearly the same area on the one system as on the other. Taking block by block, it is perhaps easier to count stock and maintain uniformity of yield. Taking the whole area *en masse* admits of the selection of the

oldest trees first, and consequently the maintenance of the highest yield, estimated by money value.

In felling by blocks, it is a matter of little consequence whether they come to the axe in the order of their geographical position or not, but it is of more consequence so to arrange them, and especially in hill country, that the young growth shall always be sheltered from the prevailing storm-winds by older forest.

But however systematically fellings may be proportioned to the annual increment at the outset, unless proper provision be made for perfect reproduction, the forests are being annihilated.

CHAPTER XVI.

WORKING-PLANS.

A WORKING-PLAN is nothing more than a proposed scheme of operations; but the term is generally used to signify that there is some system in the scheme; that it is based on more or less precisely ascertained data of the amount of standing stock of each period, rate of growth at each stage, yield of thinnings, with the order in which the several blocks require thinning; order of final clearing, with the financial results of these operations, and on a reliable method of reproduction, the costs of which have been approximately determined; and that it aims at utilising the increment, and perpetuating the capabilities of the forest, or of improving them if it has suffered from past mismanagement.

On the ordinary *Plänterbetrieb*, the principal data are restricted to the average annual increment which is cut out yearly as mature timber, and the method of working out the timber.

If a forest officer proposes to fell as much

timber as he can find a market for, and leave reproduction to take care of itself, this is his working-plan, but it is hardly a commendable one. He may realise a better revenue for many years than his more experienced brother officer, but there is danger lest it should be at the cost of the permanent deterioration of his forest.

Apart from the importance of forests in the general economy of nature, the true aim of forest administration is the realisation of the highest possible present revenue, consistent with the permanent maintenance of the capabilities of the forest; and the object of the working-plan is, by placing the Government, or the forest officer's immediate chief, in possession of all necessary data, to enable him or them to determine in how far the end is likely to be attained by the measures proposed.

A working-plan is conveniently opened with a brief descriptive account of the forests, their area, geographical position, distance from markets, with means of transport, measure of local demand, &c., with a comparison of current market rates, with ascertained rates of felling, logging, and transport.

Then taking up the blocks or subdivisions one by one, they should be classed as of the first, second, or third period, &c., according to the predomi-

nating age of the trees; then should follow particulars as to their general condition, estimated amount of standing stock, and the mode adopted in determining it, stating whether the forest is fully stocked, the condition of the forest floor, whether covered with grass or rank undergrowth, &c.; and this should be supported by a map, which is conveniently coloured with different shades of green, to enable the age of the prevailing trees of each block to be distinguished at a glance, and with some other colour or colours to denote the intermixture of other than the prevailing class of timber. And at the close, the information as to total area, area bare, area barren or unfit for forest, area stocked, with estimate of standing stock in each period of growth, may be conveniently presented afresh in tabular form.

Next might follow proposals for the method which is deemed best suited to the ascertained conditions, the order in which the several blocks are to be taken in hand, if rotation of area is determined on, estimate of stock to be felled annually, with a general budget estimate of financial results, which should be the basis of future annual budget estimates. Here, too, account should be taken of the branches and outcome of thinnings which might not repay carriage to market, with proposals for its con-

version into charcoal, or otherwise utilising it, if such intentions were entertained. Then should follow proposals for reproduction, with the experience or data on which the method has been accepted as reliable.

On the system of rotation of area, with a fairly just proportion of stock of all ages, and with moderate uniformity of soil (reproduction being ensured), it is easy to secure uniformity of yield for all time; but on the *Plänterbetrieb*, the experience of Germany has shown, not only that it is difficult to maintain uniformity of yield, but that there is commonly a temptation to secure good financial results in the present, in the hope that they may be maintained permanently, at least for our own time; and as it is difficult to determine the amount of standing stock and average rate of annual increment in a forest of trees of all ages, this hope is not always well founded. We may base our plan upon a fairly reliable estimate of trees of the final period, and may have fair data for assuming that there is an equal number of trees in the penultimate period of growth to take their place when they shall have been felled; but unless we are secure of a corresponding area of trees of each younger period, we may in time have to suspend operations, or lower the felling age by perhaps twenty years, to the lasting impoverishment

of the forest. As has been already said, we cannot trust to numbers of young trees, for if these grow in clumps, only one in many of them can ever reach maturity.

Several working-plans have been circulated among Indian forest officers, and of these, Mr Ribbentrop's working-plan of Kalu Tope in the Punjab Himalayas, although dealing only with one small block, furnishes a mass of detail in elucidation of the method pursued, which would be of great assistance to the inexperienced in preparing a working-plan. The term "reducing factor," employed by him in stock-taking, has been rendered "form figure" in these pages.

But the Indian forest officer may frequently with justice demur, that working-plans based on the theory of improving our forests up to their highest capabilities, and of utilising all their yield, is not always applicable to Indian forests, in the present relation of working costs to market value of timber. There is a general assumption that our forests have been subjected to draughts upon their resources in excess of their capabilities; but this appears to be true only of some few classes of timber which have been in excessive demand, and of which the area was in no recent period large, or which are found only in mixed forests, in which other classes of timber preponderate, for

which, although they are often first-class timbers, there is almost no demand; and, in point of fact, the annual outcome of our forests in mere quantity is almost infinitely below the productive capabilities of the area from which it is drawn. Take, for example, the Bengal forests, with an estimated area of nearly 140,000 square miles, and with an average gross annual revenue under R.140,000. Here we have in round numbers one rupee of revenue from 640 acres of forest. The framing of a working-plan for such a forest area would be influenced by manifold considerations. Limited as are the returns, they show a fair profit upon outlay; and the question arises, Could not ten times or a hundred times the present outcome of timber be disposed of at a similar profit? and if not, does not the proportion of population to forest area justify the assumption that, if the timber could be brought to market at one-half or one-fourth the present costs, it would then be in almost unlimited demand, at a figure yielding a fair profit upon the reduced costs? and if so, we should turn next to the consideration of the improvement of the means of transit.

But if the revenue were drawn only from one or two classes of timber, the yield of which was not materially in excess of the outcome, our first consideration would be a working-plan for

this special class or classes of timber, framed on the basis of promoting the spread of these timbers over larger areas, and especially in those forests nearest the market, or with greatest facilities of transport, limiting the costs of improvement to a fair proportion of current net revenue; but having done this, it would be well to form an estimate of the amount of annual increment of the less-valued timbers, and to bend our efforts to utilise it in some form, rather than let it go to decay; for if even experience shall have confirmed the view that the Department cannot take it to market at a profit upon costs, an effort might be made to sell it standing.

Assuming the whole Bengal forest area to be *bona fide* forest, the annual increment will probably not fall below twenty cubic feet per acre, and if it could be all disposed of at a profit of one rupee per twenty cubic feet, the present net revenue of the province would be multiplied two thousand times, that is to say, it would yield a net profit of 640 rupees per square mile, instead of about five annas, as at present.

It is too frequently the case that a forest officer, on assuming charge of a Division, bases his budget figures on those of his predecessors, instead of on the ascertained capabilities of the forests. The relation between costs and market

value is pretty generally known, but the relation between supply and demand is as yet an unknown quantity, and, with a profit on current transactions, the aim should be the increase of those transactions up to the capabilities of the forests. In the pursuit of this aim the demand may not keep pace with the supply, but this must not be accepted as the absolute limit of demand, but only as the limit of demand at a given price; if costs of transport can be lowered, the demand is capable of unknown expansion.

There are, unfortunately, some forest Divisions in which, if the accounts be subjected to close criticism, it will be found that the net revenue does not exceed the revenue from minor produce; in other words, the forests are being denuded of their best timber for no good end; it would be as well to give it away free on the spot, as to sell it at a distant market at a price not exceeding costs. Such a state of things must be most unsatisfactory to the officer in charge, and should tempt him to bend his best efforts to remedy it.

Indian forest-work is beset with numerous difficulties, but it is these very difficulties which the able and enterprising forest officers of to-day have to thank for rare opportunities of distinguishing themselves. The management of our forests affords scope for the highest administra-

tive ability, and, apart from any present financial consideration, the establishment of a sound system will prove a lasting benefit to the people of India.

DEPARTMENT OF AGRICULTURE
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THE END.

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